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## Proceedings of the Thirty-seventh Annual Meeting of the American Association of Economic Entomologists (*Continued*)

*Afternoon Session, Friday, January 2, 1925*

The meeting convened at 1:25 p. m., President Burgess presiding.

PRESIDENT A. F. BURGESS: The next paper is by C. H. Alden.

## SAN JOSE SCALE CONTROL WITH LUBRICATING OIL EMULSION ON PEACH TREES IN THE SOUTH

By CHARLES H. ALDEN, *Assistant Entomologist, U. S. Bureau of Entomology, Fort Valley, Georgia.*

ABSTRACT

The San Jose scale, *Aspidiotus perniciosus* Comst., has been gradually increasing on peach trees in the South in spite of annual dormant treatments with lime-sulphur. During the years 1922, '23 and '24, lubricating oil emulsions were compared with the standard lime-sulphur for scale control and tree injury. A 2% lubricating oil emulsion made from either the boiled or cold formulae gave excellent scale control and caused no tree injury, even when twice used in one dormant season Lime-sulphur gave poor control and caused some twig injury. Trees incrusted and covered with crawlers require two dormant applications of 2% emulsion for effective control while under similar conditions lime-sulphur applied twice was ineffective. Summer treatments with oil emulsions caused premature defoliation and were less effective than winter treatments.

For several years past the San Jose scale, *Aspidiotus perniciosus* Comst., has been increasing on peach trees in the South in spite of annual dormant treatments with lime-sulphur concentrate. Many complaints were received from different sections that the scale was severely injuring and killing the trees. For this reason, a series of tests with lubricating oil emulsions and lime-sulphur were begun in 1922. A particularly bad orchard in the Fort Valley section, in which there were many incrusted trees, was taken over for experimentation. This

orchard had both Elberta and Hale varieties and the different plats were sprayed with a 1, 1½, 2, and 3% home-made Government formula lubricating oil emulsion; 2% commercial lubricating oil emulsion; lime-sulphur (1 to 8); and lime-sulphur (1 to 8) with 1½ pounds of calcium caseinate to a 200 gallon tank load.

### Dormant Treatments, 1922–23

All applications were made in December, 1922, except the lime-sulphur plat which was not sprayed until January 10, 1923, owing to rainy weather. All applications were made with a power outfit having a duplex pump and a 3 H. P. engine which maintained 225 pounds pressure when using two rods with angle disk nozzles. All trees were carefully sprayed, the outfit passing down every other middle, each tree being sprayed all around before driving on. Observations were made weekly until February 21, 1923, and from 600 to 1,100 scales were examined from each plat in the Elberta orchard. Home-made Government formula lubricating oil emulsions made in the proportion of one gallon of red engine oil, one-half gallon of water, and one pound of potash fish oil soap for the stock emulsion gave the following control: 97.8% on the plat sprayed with 2% emulsion; and 85.0% on the lime-sulphur (1 to 8) plat. There were 31.8% dead scales on the untreated trees at the time of application. Control figures for the 2% emulsions are the only ones given in this paper for the different kinds and strengths of emulsions used, as this strength proved to be the best from the standpoint of cost, control, and tree injury.

This Elberta orchard had only a moderately severe infestation and was controlled satisfactorily with one dormant application of 2% lubricating oil emulsion. The Hale orchard gave quite different results as this was heavily infested and the trees covered with crawlers at the time of application.

The Hale orchard was sprayed in December, 1922, and February, 1923, but no plat received more than one application of oil emulsion as oil sprays have always been considered dangerous on peach trees and many were killed with crude oil emulsions years ago. Observations made on 700 scales per plat from the December application gave the following control: lime-sulphur (1 to 8), 75.7%; 2% emulsion, 82.6%. There were 10.0% dead scales on the untreated plat at the time of application. Owing to the poor control, these plats were sprayed again in February, the plat sprayed with oil receiving lime-sulphur and the lime-sulphur plat, oil emulsion. Observations made on 700 scales per plat from this

second application gave a control of: lime-sulphur (1 to 8), 87.9%; and 2% oil emulsion, 99.9%.

Notes were made as to injury on the different treated plats and final observations made showed no injury to twigs, buds, or trunk from any of the lubricating oil emulsions. A few twigs were killed from spraying with lime-sulphur but did not affect the crop.

Some live scales were observed in June and the Hale orchard appeared to be getting gradually reinfested from the trees that did not have sufficient control, such as those sprayed with lime-sulphur. As the San Jose scale breeds all through the winter when mild, as in 1922–23, 10% or more left alive after treatment will reinfest the orchard by the following fall.

### Late Summer Treatments, 1923

On September 4, 1923, one plat was sprayed with 2% commercial lubricating oil emulsion, and one plat with 2% cold-pumped emulsion using calcium caseinate for an emulsifier. At this time the trees were in foliage, although some few leaves had fallen. On September 11th, both plats showed a partial defoliation, mostly on the lower half of the trees. On September 18th, it was quite serious, about 25% of the foliage dropping prematurely. No bud, twig, or collar injury could be found. The scale control was: 91.8% on the 2 % commercial oil emulsion; and 85.9% on the 2% cold-pumped emulsion. There were 57.5% scales dead on the untreated trees.

### Dormant Treatments, 1923–24

The Hale orchard was treated again during the regular dormant application in December, 1923. Thirteen different plats were used, testing lubricating oil emulsion from 1 to 3% strength, and made by the commercial Government, home-made Government, light oil, and cold-pumped formulae; these were compared with concentrated lime-sulphur, a miscible oil, and the untreated plat. The cold-pumped formula made had the same proportions of oil and water as the Government formula but two ounces of calcium caseinate were substituted for one pound of potash fish oil soap, thus eliminating the necessity for heating the mixture. 1,500 scales were examined on each plat, 500 scales being examined at three different periods about two weeks apart. 1000 scales per plat were examined before the extreme cold weather in January and the results must be interpreted from these as practically all scales were killed on the sprayed plats after a temperature of 7°F. that occurred January 6, 1924. Before this cold weather the scale control

was as follows: 2% commercial Government, 99.2%; 2% cold-pumped, 97.5%; 2% home-made Government, 99.7%; 2% light oil, 98.2%; lime-sulphur (1 to 8) 86.3%; miscible oil (1 to 20), 93.5%. There were 10.4% dead scales on the untreated plat at the time of application. As in 1922, the 1923 results show a good control with a 2% lubricating oil emulsion, and a rather poor control with concentrated lime-sulphur. The difference between the cold-pumped formula and the boiled formula is slight, both giving a good scale control.

No injury was observed on any part of the tree from lubricating oil emulsion, even when as high as 3% strength was used. As in the previous year, slight twig injury was noted on the plat sprayed with lime-sulphur. All plats had some dead buds, including the untreated plat, caused from the cold in January.

### Delayed Dormant Treatments, 1924

Two plats were sprayed over in February with a 2% commercial Government formula and a 2% cold-pumped formula to get data on possible injury from two applications during one dormant season. These trees were sprayed on February 22nd, just before the buds began to swell. Observations made on March 11th, and on all succeeding dates showed no injury to any part of the tree from two applications of 2% lubricating oil emulsion when put on twice in one season.

### Treatments by Growers, 1923–24

As the peach growers used the various oil emulsions very extensively during the winter of 1923–24, it was thought advisable to make some observations on results obtained in commercial orchards. Examinations for injury and scale control were made in seventeen widely scattered places on all standard varieties of peach trees, varying in age from one to twenty-two years, and growing on all types of soil found in the peach belt. No evidence of any injury could be found from the use of 2% lubricating oil emulsions and the number of scales killed varied from 97% to 100%. No trouble was experienced with the emulsions in soft water but those emulsions containing potash fish oil soap broke down badly in hard water. Most growers were satisfied with the emulsions and were particularly pleased with its low cost and ease of application. A few growers in the northern section of the belt were afraid that leaf-curl would increase unless a fungicide was added and some would not use the emulsion on this account.

SUMMARY

Experiments made from 1922 to 1924 with lubricating oil emulsions on peach trees gave an excellent control of the San Jose scale. One application per year of a 2% emulsion was found to be sufficiently strong to effectively control a moderately severe infestation. Two applications at this strength are necessary where the trees are incrusted and covered with crawlers.

No injury to the tree could be found from the use of a 2% lubricating oil emulsion during the dormant season over a period of two years.

Late summer treatments with oil emulsions at 2% strength caused a premature defoliation and gave poorer scale control than the dormant application.

Lime-sulphur gave a poorer control than the oil emulsions used and burned a small amount of bud-wood.

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MR. H. K. PLANK: I should like to ask Mr. Alden if he took into account the difference in percentage of kill in the number of scales per branch.

MR. C. H. ALDEN: Where the trees were heavily encrusted we got a poorer control than where we had a moderate infestation.

PRESIDENT A. F. BURGESS: We will next call for the paper by Dr. Leonard.

MR. M. D. LEONARD: Mr. President and Members of the Association: I am going to take the liberty of changing the title of my paper in order to confine my remarks entirely to the Mediterranean Fruit Fly in Spain in connection with the embargo of Almería grapes to this country, and will leave until a later date some notes on applied entomology in general in Spain.

## NOTES ON THE EMBARGO OF GRAPES FROM ALMERÍA, SPAIN, ON ACCOUNT OF THE MEDITERRANEAN FRUIT-FLY (*CERATITIS CAPITATA* WIED.)

By M. D. LEONARD, *Ithaca, New York*

ABSTRACT

In the fall of 1923 grapes arriving from Almería, Spain, in New York and Boston were found to be lightly infested with the Mediterranean fruit-fly, *Ceratitis capitata* Wied. Further entry was prohibited by the U. S. Federal Horticultural Board until satisfactory evidence could be presented that the grapes were no longer attacked in Spain by this fruit-fly. The writer went to Spain to study conditions surrounding the infestation at its source. The topography of the grape growing sections in the Province of Almería, methods of culture, host-plants of the fruit-fly and amount of

infestation in Almería are described. Organization of a clean-up campaign and the results obtained are outlined. The grape embargo is closely connected with Spanish-American trade treaty relations; its probable effect on the renewal of the treaty in 1925 is discussed.

## INTRODUCTION

During the latter part of November, 1923, inspectors of the United States Federal Horticultural Board discovered a slight infestation of what appeared to be larvae of the Mediterranean fruit-fly (*Ceratitis capitata* Wied.) in the so-called Malaga white grapes arriving in the ports of New York and Boston. At this time the writer was Acting State Entomologist of New York, and as such was at once called into consultation by the Fruit Auction Company of New York City, the largest importers and sellers of these particular grapes in this country.

It was learned that, tho commonly referred to as Malaga grapes, those in question are all grown in the Province of Almería, Spain and have been imported into the United States in considerable quantities for upwards of fifty years. They are packed in cork dust and shipped in neat, well-made wooden kegs of about 50 lbs. net weight. By far the bulk of the grapes arrive here during November and December and have been greatly prized for years as a table delicacy, particularly during the Holiday season. Export figures for the last 10 years show that a normal crop is about 1,500,000 kegs of which one-third normally goes to the United States and most of the remainder to the United Kingdom.

Even tho the Mediterranean fruit-fly has been definitely known to occur in Spain since 1860 and has probably long been rather generally distributed there, Almería grapes were not heretofore known to act as carriers of the pest. It should, of course, be stated that prior to Nov. 1, 1923 when Quarantine 56 became effective, Almería grapes had been only superficially inspected upon arrival at the ports of entry in the United States. However, apparently no ill effects have resulted from the continuance of this trade in a popular commodity, so profitable to both countries concerned. Moreover, grapes in all countries, where this fruit-fly occurs, are apparently a very much unpreferred food-plant even when other fruits near by are badly infested.

Because of the unusual nature of the circumstances connected with this infestation, the writer became greatly interested in the whole situation. This interest was further strengthened when, after definitely substantiating the specific identity of the pest, the Federal Horticulture Board gave notice to the trade of a hearing to consider the advisability of prohibiting further entry of Almería grapes into this country.

## Reasons for the Embargo

The importers asked that the grapes be allowed to continue to enter. Their principal reasons were the following: the long standing clean bill of health of these grapes and the lightness of the infestation discovered; entry thru the cool northern ports of New York and Boston and only during a short period in the winter; that infested grapes were practically sound in appearance and would, therefore be eaten; and further since at least 85% of the grapes are normally sold and consumed within a zone bounded on the South by the Mason-Dixon line and on the West by the Mississippi River. They claimed they could positively confine the distribution in the future to this area providing the States outside of it would assist.

However, the Federal Horticulture Board felt that the possibility of establishment of the fruit-fly thru the agency of Almería grapes was sufficient to necessitate shutting them out of the country entirely. Therefore, further entry of grapes from Almería was embargoed until "the presentation of evidence satisfactory to the United States Department of Agriculture that such grapes are not attacked in the country of origin by injurious insects, including fruit-flies."[1]

It was evident that this embargo would probably continue indefinitely so long as the fruit-fly existed in the Province of Almería, or at least in the grape-growing districts there. Practically no first-hand information was to be had concerning the normal host-plants or their abundance and susceptibility to infestation in Almería. Therefore, the writer accepted a commission from the New York Fruit Exchange to go to Almería and make a general survey of conditions. He was there almost continuously from May 13 to Sept 10.

## Extent and Topography of Grape Sections

The Province of Almería occupies the Southeastern corner of Spain. It is irregularly triangular in shape, and is bounded on the Southwest by the Province of Granada from which it is separated by the Sierra Nevada range of mountains. On the Northeastern half it is bordered by the Province of Murcia. Outside of a narrow strip of level land bordering the coast at several points, the whole Province is mountainous, with numerous river valleys, which most of the year, however, are entirely without water. Authorative figures on rainfall and temperature are not readily available but it is very dry and warm and apparently conditions

[1] "Spanish grapes prohibited entry on account of fruit-fly infestation." U. S. D. A., Office of Sec'y. Notice Jan. 18, 1924.

closely resemble those of Arizona. Natural vegatation of all kinds is almost entirely lacking, and in order to grow crops, irrigation is essential. Considerable fertilizer is also necessary.

The commercial life of the Province is almost entirely dependent upon grapes, which are exported chiefly to the United Kingdom and the United States. These are suitable for table use only, since the sugar content is not sufficient to make them valuable for wine. Scattered deposits of iron, lead and copper, which are at present not being worked to any extent, and small plantings of oranges and almonds form practically the only other products for export.

The grapes are grown chiefly in the dry river valleys, but are also cultivated along the level coastal strip. The vineyards are often terraced far up on the mountain sides. They may be found from sea level to over 5,000 feet upon the slopes of the Sierra Nevadas, themselves. The chief factor influencing the location of the vineyards is availability of water for irrigation. In some cases, this water is carried from springs or reservoirs for many miles in open cement troughs.

The territory including the principal grape-growing sections occupies considerably less than half the area of the Province. It may be roughly described as an irregular fan-shaped section, radiating from the City of Almería as a center, which is located near the center of the southern coast. Several sections are separated one from the other by barren stretches and by mountain barriers. This region extends about 25 miles to Berja on the West of Almería and about 7 or 8 miles to Alquian on the East. The Northwestern extremities include Canjáyar and Gérgal and towns along the railroad to Fiñana, near the border of the Province. Toward the Northeast are included Tabernas and Sorbas. Though not important producing sections, Vera and Huercal-Overa should also be included. I should say that 90% of the production is within a radius of 25 miles of Almería and by far the bulk of this lies to the West and Northwest.

## General Conditions and Fruit-Fly Campaign

Immediately upon my arrival I made a preliminary examination of conditions in several of the principal grape-growing sections with a view to becoming familiar with the topography and the general methods of culture, and especially to gain an idea of the kinds and relative abundance of possible host-plants and their proximity to the grapes.

Such a survey showed that the possible host-plants were figs, prickly pear, orange, plum, pear, apple, quince, apricot, tomato, bell pepper and, of course, grape. None of the fruits tho generally distributed, except

grapes, were grown commercially, save for oranges in two or three adjoining towns. Prickly pears were common and were almost everywhere. Figs were fairly common and were practically a roadside weed. The remaining fruits were mostly grown in home gardens or often along the edge of a vineyard and were used simply for home consumption, or the small surplus might be sold in the local market. Tomatoes were not abundant but somewhat generally distributed in small plantings in the lower sections. Bell peppers, tho grown, were less common than tomatoes. I should say that of all fruits grown in the province, grapes constituted 90%; of the remaining 10% figs constituted probably 75%.

Grapes were vital to the commercial life of the province and all other possible host-plants were, in comparison, of small value and in the aggregate, not so very abundant. I was, therefore, convinced that by destruction of these hosts, or at least their fruits, the fruit-fly population could be so reduced that by the time the grapes began to ripen in September, there would be practically no danger of their becoming infested. I also proposed to supplement this operation by drenching the soil under all fruit trees at frequent intervals with some solution to destroy the puparia and by spraying once every week or ten days with a poison bait spray to kill the flies.

Sr. D. Jaime Nonell, Agricultural Engineer of the Province of Barcelona, who is one of the leading applied Entomologists in Spain, had been appointed by the Spanish Department of Agriculture in general charge of fruit-fly work in Almería. On his arrival, the latter part of May, I presented this program to Sr. Nonell and the members of the Official Grape Commission of the Province. I explained that I felt it was not at all impossible of accomplishment but that determined, thoro cooperation of all growers was absolutely necessary. They agreed to carry out this program but with certain modifications, particularly in the matter of wholesale destruction of fruit trees which they felt was unnecessary. For the time being, I did not believe it well to press this point. I strongly urged an immediate start, however, since some fruits would be ripe shortly and I felt the fruit-fly should soon be found, tho Sr. Nonell did not think adults would emerge from the ground until early July.

Sr. Nonell then returned to Barcelona, but by Royal Decree of June 3, there was appointed a Sanitary Brigade consisting of an Agricultural Engineer, Sr. D. Juan de la Cruz Soler in charge, and five assistants. D. Fernando Silvela, Chief of the Agronomical Section of the Province was also appointed a cooperator. This brigade did not arrive, however,

till the first week in July. It had not been possible as yet to find adult fruit-flies, but apricots had just started to show evidences of slight infestation. The province was divided into six zones and an assistant placed in the field in charge of each. Copies of a circular containing information concerning the fruit-fly and measures to be carried out were circulated among all the growers. My rôle was largely that of consulting expert.

## Food-Plants and Infestation

Between the latter part of June and early August, the plants actually found to be infested during the season were both in order of abundance and of infestation: peach, apricot, pear, quince, orange and tomato. The first three showed moderate to light infestation in most sections. Brief notes on these food-plants follow:

Peach. Moderately infested during the latter part of June and first half of July in most towns, after which peaches were about over. A somewhat greater infestation, however, was found in peaches in the Almería market the middle of August. These were said to have come from Laujar, a small town on the southwestern border of the province.

Apricot. Found infested in several towns during the latter part of June and early July. Only a few fruits were infested, however, with an average of three or four larvae each. Fruits examined in the market and hotels in the city of Almería were somewhat more generally infested. Many of these, I was told came from the province of Granada.

Pear. Moderate infestation was observed chiefly in the lower towns, mostly from the middle to the latter part of July. However, pears were found in the market in Almería the latter part of August with somewhat greater infestation. These, like the peaches mentioned above, were seen to come from Laujar.

Quince. Grown to a less extent than most other fruits, except possibly apples. Only four or five fruits each containing but one or two larvae, in two towns near Almería, were found infested. This was in early July.

Orange. Confined almost entirely to a small section including two or three towns near Almeria and here grown commercially in several fair-sized plantings. The season ended about May first and oranges would not be ripe again till November or December. Oranges in hotels in Almería during May and early June were often badly infested. These I was told, however, came from the Province of Murcia. Dr. Wm. A. Mann, however, after examining old oranges on the ground near the

town of Gádor about the middle of August, said they showed typical evidences of having been infested.

TOMATO. It is here included as a definite food-plant, but only one fruit containing one larva was found during the whole season.

Other possible host-plants, except figs, were not found infested.

FIG. Dr. Wm. A. Mann, of the United States Bureau of Entomology spent the month of August in Almería to examine fruit-fly conditions and report to the Federal Horitcultural Board. Upon his arrival the first week in August, the previous moderate infestation in all host-plants was no longer to be found, since the season of ripening was practically over. Just before the middle of the month, however, the earliest ripening figs began to show signs of infestation and, by the latter part of the month, figs in a stage susceptible to attack, were found infested in most of the towns examined. In several towns, prematurely fallen figs on the ground under large trees contained as high as ten or twelve larvae with an average of four or five to nearly every fig.

When this fact was reported to the Federal Horticultural Board, word was received the last of August, that the embargo could not be lifted that season.

GRAPES. Thousands of grapes were examined in all sections from the time they first began to show signs of ripening until Sept. 10, but none were ever found to be infested.

The above decision of the Board was, apparently, thot necessary on the basis that even tho grapes were apparently clean, the fruit-fly was still present in the grape sections. Grapes, having been proved susceptible to infestation the previous season, would, therefore, be potential carriers of the pest to the United States should they be allowed to enter.

This decision was held to, despite active and organized efforts of both the growers and importers to obtain at least some modification. Since it had not been possible to destroy all the figs, the growers felt that the fruit-fly would not leave the figs for grapes, at least until the figs were done, which would not be until almost the middle of October. They, therefore, asked permission for entry of all grapes picked during September. Two important grape-producing towns—Dalías and Alhama—had earlier cut down almost literally every suspected host-plant of the fruit-fly and were felt to be, for all practical purposes, free from the pest. These were high and isolated from surrounding grape towns by at least five miles of barren stretches and mountain barriers. A third town, Enix, even higher and more completely isolated than these, had practically no host-plants to start with, and the few there were had been

cleaned out. The importers felt that it would be safe for at least part of the grapes to be shipped from at least one of these three towns under permit and offered to guarantee that no grapes from any other towns would be included. This guarantee could undoubtedly have been strictly held to, since the exporters would have jealously guarded against inclusion of outside grapes, because of the exceptional prices which would have been obtained in the States.

The Board took the attitude, however, that any concession at all would be taking a chance of introducing the fruit-fly into the United States and refused to run any risk whatsoever.

### Effect of the Embargo on Spanish-American Trade Relations

The effect of this embargo upon general trade relations with Spain is difficult to predict at the present time. That it will be at least a measurable one however, is fairly certain to say. It is improbable that the people of Almería will be able, for sometime to come, to reduce the fruit-fly population of their province to a point at which the Board would admit it is practically eliminated. Therefore, export to the States, which normally has been about one-third of the total crop, will remain cut off and best opinion predicts that prices in other markets will tend to approximate cost of the grapes or little better. Apparently, it will take years to develop other markets for the present sized crop, if indeed it can be done at all, which is rather doubtful. If production is curtailed, it will mean ruin to a large number of growers and exporters whose only possible source of livelihood is grapes.

Naturally the people of Almería, particularly, but also agricultural exporters in other parts of Spain are unable to understand our attitude in this matter. The agricultural interests in Spain have now for the first time become organized into a well-knit body with official representation in the Board at Madrid, which regulates trade treaties between Spain and other countries. Moreover, our importing interests feel that they are being unjustly deprived of a business of long time standing and the consuming public of a commodity, which could have been preserved for the present at least, in part.

The present trade treaty between Spain and the United States terminated May 5, 1924, but was prorogued for one year with the hope that the grape embargo could be lifted to admit the crop of 1924. The writer was continually in close touch with the highest Spanish Government officials and prominent agriculturists in Spain as well as with the Hon. Alexander P. Moore, the United States Ambassador to Spain and Mr. James G. Burke and Albert Noel, representatives of the United States

Department of Commerce in Madrid. At the time of my departure, it was the general feeling that every effort would be made by Spanish agricultural interests to place obstacles during the coming year in the way of favorable conditions for export of many American products to Spain.

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PRESIDENT A. F. BURGESS: The next paper is by J. J. Culver.

## THE VALUE OF THE DRY SUBSTITUTES FOR LIQUID LIME SULPHUR AS A CONTROL FOR SAN JOSE SCALE

By J. J. CULVER, *Vienna, Va.*

(Withdrawn for Publication Elsewhere)

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PRESIDENT A. F. BURGESS: We will take up the first paper on the afternoon program, by W. S. Abbott.

## A METHOD OF COMPUTING THE EFFECTIVENESS OF AN INSECTICIDE

By W. S. ABBOTT, *Bureau of Entomology, United States Department of Agriculture*

In computing the effectiveness of insecticides, when an actual count of the living and dead insects in both the treated and untreated plats, or checks, is available, it is obvious that the insects which die from natural causes must be considered. Just what weight should be given to this factor, and how its value is to be determined, seem to vary with the individual experimenter.

Perhaps the most common method is to subtract the percentage of dead in the check plat from the corresponding figure for the treated plat and call the remainder the effectiveness of the treatment. If the mortality in the check is very low this method may be fairly satisfactory, but if, for example, the check shows 50 per cent dead and the treated plat 98 per cent dead, then the effectiveness, determined by this method, would be only 48 per cent.

This matter of the proper evaluation of the check is not of great consequence when a series of tests is based on one check, but becomes highly important when experiments based on different checks are compared.

For the last five years the entomologists of the Insecticide and Fungicide Board have been carrying on a rather extensive series of experiments with treatments against the San Jose scale, and in attempting to

compare their results a method of computing what may be termed the "per cent control" has been developed.

This method is based on the following line of reasoning:

1. The difference between the percentage of living scales in the untreated check and the percentage of living scales in the treated plat gives the percentage of the original number actually killed by the treatment.

2. When a certain number of scales, as for example 20 per cent, is found to have died from natural causes, it logically follows that only 80 per cent of the original infestation was living and could have been killed by the treatment applied.

3. Since only 80 per cent of the insects could have been killed by the spray the "per cent control" would be determined by comparing the number actually killed with the number of *living* scales in the check. This may be reduced to a simple formula as follows:

Let X = the per cent living in the check.

Let Y = the per cent living in the treated plat.

Then X—Y = the per cent killed by the treatment.

And the per cent killed by the treatment (X—Y) divided by the per cent living in the check (X) gives the control, or expressed by an equation,

$$\frac{X-Y}{X} \times 100 = \text{per cent control.}$$

The following examples show how this method works out in actual practice.

| Example | Per cent living in check X | Per cent living in treated plat Y | Difference (X—Y) | Significance of Difference | Per cent control $\frac{X-Y}{X}$ |
|---|---|---|---|---|---|
| 1 | 45.0±1.5 | 19.5±1.07 | 25.5±1.84 | 13.8 | 56.6±2.77 |
| 2 | 45.0±1.5 | 2.4±0.22 | 42.6±1.51 | 28.2 | 94.6± .52 |
| 3 | 83.8±0.8 | 30.3±1.38 | 53.5±1.59 | 33.8 | 63.8±1.67 |
| 4 | 83.8±0.8 | 3.6±0.37 | 80.2± .88 | 91.1 | 95.7± .44 |

The "per cent control" secured by the use of this formula is obviously no more accurate or significant than the original data on which it is based. It should therefore not be used until the reliability of the figures for the percentage of dead in the check and treated plats has been carefully considered. This can be done by computing the probable error for each set of counts and then determining the significance of the difference between the two counts.

It is generally considered by biometricians that, when the difference between the results obtained in two experiments is more than three times its probable error, the results are significant, that is, if the quo-

tient obtained when the difference is divided by its probable error is over three we can say that the difference is probably not due to chance but to the treatments applied.

The probable errors for X, Y, and X—Y are given in the table above.

These typical cases show how a high or low check affects the "per cent control," and it should be noted that when a high percentage of efficiency is found the "per cent control" does not materially reduce this figure.

As far as I am aware this method has not been generally used by entomologists, but it seems to offer a reliable means for comparing results when several series of experiments have been carried on, each based on a different check.

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MR. PHILIP GARMAN: I would like to ask Professor Abbott if there is any difference in the formulae used for computing the probable error by different persons experimenting with this kind of work.

MR. W. S. ABBOTT: I think Mr. Hartzell in a paper before this Society last year gave three different formulae, and there are different methods.

MR. PHILIP GARMAN: How do you decide which method is the proper one to use?

MR. W. S. ABBOTT: It is up to the entomologist to make the choice for himself.

PRESIDENT A. F. BURGESS: The next paper is by Albert Hartzell and F. H. Lathrop.

## AN INVESTIGATION OF SULFUR AS AN INSECTICIDE[1]

By ALBERT HARTZELL and F. H. LATHROP

SUMMARY

The toxicity of sulfur and some of its compounds was tested under laboratory and field conditions. Atmospheres containing the volatile products of lime-sulfur were found to produce lethal effects on San Jose scale (*Aspidiotus perniciosus*), especially on the young. Tests on the covers of this species indicate that they are very slightly, if at all, soluble in lime-sulfur and the common wax solvents such as benzene, xylene and turpentine.

Three new sulfur insecticides were invented during the progress of this investigation. (1) Carbon disulfide-sulfur emulsion was made by emulsifying soap and water with carbon disulfide containing dissolved sulfur. Promising results were obtained

[1]Conducted under the direction of The Crop Protection Institute, as a part of a project financed jointly by the Freeport Sulphur Company, the Texas Gulf Sulphur Company, and the Union Sulphur Company.

with this preparation in the control of pear psylla (*Psylla pyri*) and as a dormant spray for San Jose scale. (2) Sulfur-naphthalene dust was prepared by dissolving flowers of sulfur in melted naphthalene, then rapidly chilling the solution and grinding the solid thus formed into a dust by means of a ball mill. As a greenhouse insecticide this dust has proved effective against red spider (*Tetranychus* sp.) and aphids. (3) A colloidal sulfur was prepared by passing sulfur fumes into a dispersion medium, such as soap and water or glue and water. This method of manufacture has an advantage in that it obviates the necessity of changing the sulfur to some other form and recovering it again by chemical means. Field tests indicate that this preparation compares favorably with other colloidal sulfurs in the control of insects and apple scab.

## Introduction

The junior writer was appointed to the Sulfur Fellowship in October, 1922, and began work at Ohio State University. On July 1, 1923, the project was taken over by the senior author[2] and carried on at the New York State Agricultural Experiment Station, Geneva, New York. Upon his appointment as entomologist of the Boyce Thompson Institute for Plant Research, Inc., the work was transferred to Yonkers, New York, and conducted there as a half-time project from April 15 to August 31, 1924.

The object of the investigation was to determine the value of sulfur as an insecticide, its toxicity to foliage, and its general utility as a means of controlling insects. The problem has a direct bearing on the still more fundamental question of the manner in which sulfur causes the death of insects.

Until recently the use of sulfur as an insecticide has been confined chiefly to the destruction of mites, and in combination with lime in the form of lime-sulfur, for the control of scale insects. This investigation has indicated that sulfur has a wider field as an insecticide than has generally been conceded to it, and that it only awaits intensive study to reveal its possibilities. New forms of sulfur are being prepared and tested as to their insecticidal properties, and the wide range of chemical activity that this element possesses makes the outlook promising.

Unusual opportunities have been afforded the writers to note the utility of sulfur in various forms as an orchard spray. For a number of years the New York Agricultural Experiment Station has been conducting extensive investigations to determine the effect of sulfur on the quality of fruit and on injurious insects, and to observe the action of

[2]We wish to express our indebtedness to the Ohio State University, the New York Agricultural Experiment Station and the Boyce Thompson Institute for Plant Research for many courtesies, for the privilege of using laboratory facilities, and for assistance rendered by members of the technical staffs of these institutions. We desire especially to express our appreciation of the assistance of Dr. Herbert Osborn, Prof. P. J. Parrott and Prof. W. C. O'Kane.

combinations of sulfur with the arsenicals and with nicotine. The trend of these studies indicates that sulfur has properties that tend to make it a good insecticide, and that its possibilities have not been used to the fullest extent in general orchard practice.

Our investigation has followed two major lines of effort, briefly outlined as follows:

1. The toxicity of sulfur and its compounds on insects.
2. The preparation and testing of new sulfur insecticides.

## Toxicity of Sulfur

The investigations on the toxicity of sulfur were conducted along two lines. First, to observe the action of elemental sulfur on soft-bodied insects, on the basis that these forms are less resistant to its toxic property and therefore more likely to furnish a clue to the way in which sulfur kills. Second, to note the effects of sulfur compounds on species which are highly resistant to contact sprays because of their natural protection. The Coccids are among the best examples of the latter type and present a separate problem in themselves.

The larva of the common fruit fly (*Drosophila melanogaster*), was selected as a promising example of a soft-bodied insect with which to make toxicity tests. The insects were reared on apple pulp in battery jars until required for study, when they were removed to Petri dishes. The following procedure was adopted in conducting the experiments:

About 10 grams of apple pulp was spread in a Petri dish and a definite number of larvae were removed from the rearing cages and placed on the moist pulp. After the larvae had buried themselves beneath the surface, flowers of sulfur (5 grams) was sprinkled over the contents of the dish, care being taken to scatter the powder evenly. The comparative toxicity of 10 cc. of mercuric chloride 1–1000 and 5 grams of boracic acid was determined by substituting these poisons in place of sulfur in another Petri dish. Check experiments were run in a similar manner by placing larvae on discs of moist filter paper and supplying bits of apple pulp for food. In these experiments the larvae were confined in the Petri dishes for 16 hours at room temperatures.

Table 1.—Comparative Toxicity of Flowers of Sulfur to Fruit Fly Larvae

| Toxic Substance | Percentage killed | No. larvae used |
|---|---|---|
| Flowers of Sulfur | 95.0 | 260 |
| Mercuric Chloride 1-1000 | 99.1 | 120 |
| Boracic acid | 40.0 | 100 |
| Check (no treatment) | 0 | 100 |

The results as shown in Table 1 indicate that flowers of sulfur is slightly less toxic to fruit fly larvae than mercuric chloride 1–1000 and considerably more toxic than boracic acid.

Having determined in a limited way that sulfur possessed considerable toxicity when applied to soft-bodied insects, it was next attempted to note the effects of sulfur on insects that are better protected.

Scales of Coccids have generally been considered as composed of wax. It was shown by Maulik[3], however, that the scale covering of *Lepidosaphes ulmi* is not soluble in the ordinary solvents of wax and that in addition it contains nitrogen. He concludes that the composition of the covers is not a wax in the restricted sense of the term. Shafer[4] finds that lime-sulfur has the power of softening the newly secreted portion of the covers of *Aspidiotus ficus*, thus causing the insect to adhere to the bark of the tree. Harukawa[5], a Japanese investigator, has shown that lime-sulfur will not appreciably dissolve the scale covers of *Aspidiotus duplex* even when immersed in the solution for 14 days. This is in line with Maulik's observations as to the insolubility of the scale covering of *L. ulmi* in xylene, benzene and turpentine.

In order to secure further information as to the effects of lime-sulfur on the covering of scale insects a series of experiments was initiated using the San Jose scale (*Aspidiotus perniciosus*), which is relatively both abundant and economically important. Apple twigs infested with San Jose scale were painted with lime-sulfur solution[6] at full strength, at dilutions of 1–4 and at 1–8, to determine whether this material will dissolve or soften the wax of this species. The treated scales were examined at regular intervals to note the effects on the scale covers. A slight softening of the secretion around the margin of the scale was observed within twenty-four hours after treatment, but it was not sufficient to cause the insect to adhere to the bark of the twig. Longer exposure did not seem to increase appreciably the softening of the scale covering. In three days the insects showed a change in color and appeared to be dead, as they did not respond to probing with a needle bearing a slight electrical charge.

It was next attempted to demonstrate by another method whether the scale covers are soluble in lime-sulfur. Twigs infested with scales were boiled for fifteen minutes in concentrated lime-sulfur solution

[3]Maulik, S., Bul. Ent. Res., Vol. 8, pp. 267–269, 1916–17.
[4]Schafer, G. D. Mich. Agr. Expt. Sta. Tech. Bull. 11, pp. 53–64, 1911.
[5]Harukawa, Chukichi, Berich. Ohara Inst. f. landw. Forsch., Band II, Heft 1, pp. 1–20, 1921.
[6]Rex lime-sulfur, concentrated solution, 32° B.

testing 32° Baume. The covers for the most part remained intact but showed a very slight softening around the margins.

Also wax solvents were tried. Scale covers were immersed in boiling xylene for fifteen minutes; but little, if any, solvent action was noted.

To determine whether the factor of time is important, covers were removed from scale insects and placed in vials containing concentrated lime-sulfur (32° B), and dilutions of lime sulfur ranging from 1–4 to 1–8. The scale covers did not completely dissolve after remaining in the above mentioned solutions at room temperatures for more than six months. The high insolubility of the covers of the San Jose scale in lime-sulfur renders questionable the theory advanced by certain writers that lime-sulfur kills scale insects by dissolving away the "wax" and coming into direct contact with their bodies.

As a possible clue to the action of lime-sulfur on Coccids, tests were made on the toxicity of the volatile products of lime-sulfur. The following procedure was carried out in conducting these experiments: A definite amount of lime-sulfur solution (50 cc.) was placed in the bottom of each one of a series of fruit jars. In each jar an apple infested with San Jose scale was suspended within two or three inches above the surface of the solution by means of a piece of twine tied to the stem. The jar was then tightly sealed. As a check to this series of experiments infested apples were suspended in a similar manner over tap water. The insects were exposed for periods ranging from twenty-four to forty-two hours at room temperature. In checking the results 100 individuals were examined in each case and the percentage of dead scales determined.

The results are presented in Table 2. It will be noted that exposure over full strength solutions killed 85 per cent of the adults while dilutions of one to four and one to eight gave 80 per cent and 56 per cent respectively. The young were more susceptible than the adults, showing 96 per cent for the full strength lime-sulfur, and 88 per cent for the one to four, and 64 per cent for the one to eight.

TABLE 2.—TOXICITY OF THE VOLATILE PRODUCTS OF LIME-SULFUR TO SAN JOSÉ SCALE

| | Full strength | 1–4 | 1–8 | Check |
|---|---|---|---|---|
| Per cent adults dead | 85 | 80 | 56 | 2 |
| Per cent young dead | 96 | 88 | 64 | 1 |

From this it was concluded that the volatile products of lime-sulfur possess considerable toxicity especially to young scale insects when exposed for a considerable period in a confined space. The results in-

dicate that under certain conditons lime-sulfur solution possesses lethal effects upon San Jose scale without actual contact with the insect. The manner in which these effects are produced was not determined.

## Reduction in Size of the Sulpur Particle by Mechanical Means

Through the cooperation of the Premier Mill Corporation of Geneva, New York, it was possible to make a number of tests to determine the degree of fineness to which this mill would reduce flowers of sulfur. The sulfur was suspended in water and run through the mill. The results are indicated in Table 3. It will be noted that a reduction of 47.6 per cent was obtained in the size of the sulfur particles with four grindings. Microscopic measurements of the sulfur particles were made before and after grinding, measuring at random the largest particles that were observed in the field of the microscope. Recently our attention has been called to a sample of sulfur paste which was made by this mill in England in which the largest particles were 6 microns in length and the majority fell between one-half micron and one micron in length. If this method proves successful it may be possible to get sulfur in as fine a state by mechanical means as by precipitation.

Table 3.—Microscopic Measurements of Sulfur Particles Before and after Grinding

| Materials in water suspension | Av. size of sulfur particles before grinding | Av. size of sulfur particles after grinding | Percentage reduction | Size of Rotor | Number of revolutions per minute | Clearance set up | Number of grindings |
|---|---|---|---|---|---|---|---|
| | microns | microns | | inches | | inch | |
| 6.5 ozs. flowers of sulfur 7 lbs. 10 ozs. water.... | 83.0 | 43.5 | 47.6 | 15 | 3000 | .001 | 4 |

## Preparation and Testing of New Sulfur Insecticides[7]

### carbon disulfide-sulphur emulsion

In order to develop a liquid sulfur insecticide in which the sulfur was present in the finest possible state of division, it occurred to us to dissolve sulfur in some liquid that lends itself readily to emulsification. Carbon disulfide was used for this purpose since it appeared to be the best solvent available and is easily emulsified with soap and water. Two methods were employed in making up the solutions. In one the sulfur was dissolved in carbon disulfide until a saturated solution was obtained; in the other a definite amount of sulfur was added to the car-

[7]Patents have been applied for these processes and materials, on behalf of the Crop Protection Institute.

bon disulfide, the quantity used being less than enough to saturate the solution.

The solutions of carbon disulfide and sulfur were emulsified in the following manner: Water solutions of soap, glue, gelatine and nicotine oleate were prepared. The solution of carbon disulfide and sulfur was slowly added to each, while vigorously agitated until a creamy white emulsion was formed. Soaps, especially potash fish-oil soap and nicotine oleate, proved to be the best emulsifiers, while on the other hand gelatine and glue made rather unstable emulsions. Our experiments indicate that the relative proportions of the ingredients affect the stability of the emulsion. It was noted that when sulfur was omitted from an emulsion of carbon disulfide and soap, the mixture had a tendency to separate into layers and that the degree of stability is in direct proportion to the amount of sulfur in solution, up to the point of saturation.

During the season of 1923 a series of field experiments were conducted to test the insecticidal value and the degree of toxicity to foliage of several emulsions. A stock solution was prepared as noted below and then diluted with water. To increase the insecticidal effects of the emulsions other materials were added to the stock solution. As the possible harmful effect of these sprays on foliage was not known, experiments using large numbers of mature trees were not practicable. Therefore, the alternative of spraying individual trees was resorted to. Field tests were made at Geneva and Highland, New York, and the spray applied by means of a small compressed air sprayer.

The stock solution that formed the basis of most of these tests was made up as follows: A soap solution was prepared by dissolving 5 grams of potash fish-oil soap in 200 cc. of water. In another container one gram of flowers of sulfur was dissolved in 250 cc. of carbon disulfide. While the soap solution was being agitated the solution of carbon disulfide and sulfur was slowly added and the agitation continued until a creamy white emulsion was formed. The stock solution thus prepared could be diluted with water to whatever strength required.

Small apple trees heavily infested with *Aphis pomi* were sprayed with dilutions of the above solutions ranging from 1:10 to 1:100. It was noted that injury to foliage resulted when concentrations greater than 1:20 were applied. At that strength approximately 75 per cent of the aphis were killed.

It occurred to us that a relatively small amount of nicotine oleate[3] added to the stock solution might increase its effectiveness. A solution

[3]Moore, William. Jour. Econ. Ent., Vol. 11, No. 3, p. 341, 1918.

of nicotine oleate was prepared by using 12 cc. of oleic acid and 20 cc. of nicotine (Nicofume) dissolved in 200 cc. of water. To this mixture 100 cc. of the stock solution was added and the combined emulsion diluted with water to the required strength.

On October 8, 1923, four Bartlett pear trees heavily infested with pear psylla (*Psylla pyri*) at Highland, New York, were sprayed with the combined carbon disulfide and nicotine oleate emulsion. Two trees received applications with dilutions of 1:75 and two trees with dilutions of 1:40. The results obtained showed a kill of 97 per cent of adult psylla on the trees sprayed with the 1: 40 dilutions, while those sprayed with the less concentrated preparation were unsatisfactory. There was no evidence of injury to the foliage on any of the trees sprayed.

In the fall of 1923 a number of field experiments were conducted at Geneva, New York, to study the relative toxicity of the stock solution of the carbon disulfide-sulfur emulsion on San Jose scale (*Aspidiotus perniciosus*) as compared with lime-sulfur solution. The number of "black" scales on a definite area of an apple twig was used as the basis of comparison. The scales were carefully counted and a band of cotton batting was tied around the limb above the area examined to prevent the young scales from migrating and the twig from being reinfested. The twigs then received a single application of carbon disulfide-sulfur emulsion, ordinary carbon disulfide emulsion, or lime-sulfur. Either glue or calcium caseinate (Kayso) was combined with the spray in certain instances as indicated in the table. At definite intervals, ranging from three days to three weeks, twigs were removed from the trees and the scales carefully examined under the microscope to determine the number of dead and living adults.

From Table 4 it will be noted that carbon disulfide-sulfur emulsion

TABLE 4.—COMPARISON OF THE TOXICITY OF CARBON DISULFIDE-SULFUR EMULSION AND LIME-SULFUR ON SAN JOSÉ SCALE

| Treatment | Dilution | No. black scales before treatment | No. live scales after treatment | Per cent dead |
|---|---|---|---|---|
| Carbon Disulfide-Sulfur Emulsion | 1:10 | 230 | 5 | 98 |
| Carbon Disulfide-Sulfur Emulsion | 1:20 | 488 | 10 | 98 |
| Carbon Disulfide-Sulfur Emulsion and Glue 1:100 | 1:20 | 92 | 8 | 96 |
| Carbon Disulfide Emulsion (without Sulfur) | 1:20 | 40 | 30 | 75 |
| Lime-Sulfur and Glue 1:100 | 1:8 | 183 | 33 | 82 |
| Lime-Sulfur and Kayso 1:100 | 1:8 | 162 | 18 | 90 |
| Check | —— | 100 | 89 | 11 |

when applied at dilutions of 1:20 showed a kill of 98 per cent as compared with 90 per cent when lime-sulfur and Kayso were used. The table also shows that the addition of sulfur greatly increases the toxicity of the carbon disulfide emulsion.

### SULFUR-NAPHTHALENE DUST

It was found by experiment that flowers of sulfur are readily soluble in melted naphthalene, and that the resulting solution has a lower melting point than sulfur alone. Flake naphthalene and flowers of sulfur (Niagara No. 102) were melted together, using various proportions. The melted solution of naphthalene and sulfur was poured into galvanized iron tubs and chilled by ice packs. This apparently prevented separation of the sulfur and naphthalene and the two formed a solid solution which when cooled was broken up and ground to a dust in a ball mill. The proportion of sulfur and naphthalene was varied and a series of solid solutions made up with the ratio of naphthalene to sulfur ranging from 1:1 to 1:15. It was found that solutions made of equal parts of sulfur and naphthalene ground more satisfactorily. A dust made as described above by using equal parts of the two constituents was tried out on aphids under greenhouse conditions. The results appear in Table 5, which show that over 98 per cent of the aphids were killed by a single application of this dust. No injury to the foliage of Spirea was observed.

TABLE 5.—EFFECT OF SULFUR-NAPHTHALENE DUST ON MYZUS PERSICAE

| Number aphis | Hours of Exposure | Number Alive | Number Dead | Percentage Killed | Host | Temperature Range |
|---|---|---|---|---|---|---|
| 400 | 24 | 5 | 395 | 98.8 | Spirea | 60°-65°F. |

The toxicity of sulfur-naphthalene dust to red spider (*Tetranychus* sp.) was tested by removing infested peach leaves from seedlings and placing them in Petri dishes. In order to prevent the leaves from drying out moist filter papers were placed in the covers. A series of infested leaves were dusted as indicated in Table 6. Of these dusts, one consisted of two-thirds sulfur (by weight) and one-third naphthalene; the other combined equal parts of the two ingredients. Comparative tests were also run with flowers of sulfur alone and ground naphthalene alone. The number of live and dead mites was carefully noted at intervals of twenty-four hours. At the end of forty-eight hours the mites that were dead had changed from their normal color to black, the color intensity being most pronounced in the individuals killed by dusts in which sulfur was an ingredient. In order to be positive that there was no re-

covery after exposure to these dusts, the mites were removed at the end of seventy-two hours and examined a day later. None responded to probing with a hot needle. From Table 6, it will be observed that perfect control was obtained in all cases, except with flowers of sulfur. While ground naphthalene is very effective against mites it cannot safely be applied to foliage as it causes severe burning. The sulfur-naphthalene dusts, on the other hand, possess great toxicity to mites, and are less injurious to the foligage. Greenhouse experiments and field tests on the toxicity of sulfur-naphthalene dusts to foliage indicate that they possess a considerable margin of safety when properly applied. As plants differ greatly in their susceptibility to injury by naphthalene it is recommended that trials on a small scale precede dusting involving a large number of plants.

TABLE 6.—COMPARATIVE TOXICITY OF SULFUR-NAPHTHALENE DUST TO RED SPIDER

| Treatment | 24 hours | | | | | | 72 hours | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Young | | | Adults | | | Young | | | Adults | | |
| | alive | dead | % dead | alive | dead | % dead | alive | dead | % dead | alive | dead | % dead |
| Sulfur-Naphthalene Dust (⅔ Sulfur, ⅓ Naphthalene) | 0 | 131 | 100 | 0 | 101 | 100 | | | | | | |
| Sulfur-Naphthalene Dust (Equal parts) | 0 | 115 | 100 | 0 | 49 | 100 | | | | | | |
| Flowers of Sulfur | 87 | 29 | 25 | 30 | 29 | 49.1 | 1 | 115 | 99.1 | 25 | 34 | 57.5 |
| Naphthalene (ground) | 0 | 160 | 100 | 0 | 47 | 100 | | | | | | |
| Check | 209 | 3 | 1.4 | 37 | 0 | 0 | 208 | 4 | 1.7 | 33 | 0 | 0 |

COLLOIDAL SULFUR

Two forms of colloidal sulfur were prepared in the course of these investigations. In one, (No. 1), naphthalene in varying proportions was used to lower the boiling point of sulfur. At the same time a hot solution of 5 grams of potash fish-oil soap and 100 cc. of water was prepared in a separate container and added slowly to the sulfur and naphthalene and agitated two minutes. This forms a creamy white paste. By adding 50 parts by volume of water to this paste and agitating again for one minute a white colloidal sulfur is formed. Microscopic examination of this product shows that most of the particles range from .5 micron down.

Later another, (No. 2), method of making colloidal sulfur was devised by causing sulfur fumes to enter a solution of soap and water. This preparation was made in the laboratory as follows:

A definite amount of flowers of sulfur was placed in a flask, and

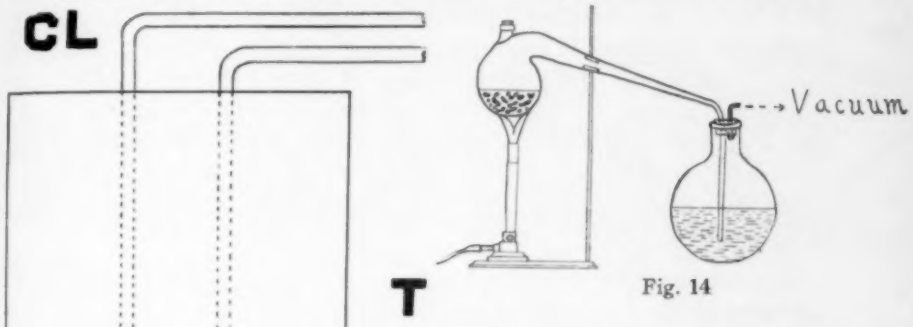


Fig. 14

nitrogen was forced through to drive out the air. The flask was heated by means of a Bunsen burner and after copious fumes were evolved nitrogen was again introduced to force over the sulfur fumes into the soap solution. The soap and water solution was made by dissolving 5 grams of potash fish-oil soap in 50 cc. of water. Nitrogen gas was employed in preference to other gases because it is inert. It also serves in a mechanical way to agitate the soap and water solution. It was calculated that the stock solution of colloidal sulfur made in this way contained sulfur at the rate of 8 pounds to 100 gallons. Glue or gelatine may be substituted for soap, but do not make colloidal solutions of the same stability. Dilutions of the concentrated solutions were made which remained per-

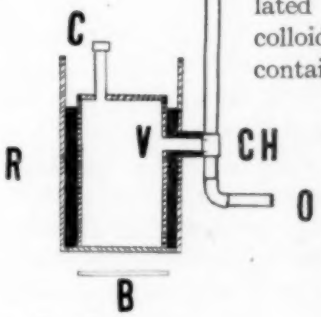


Fig. 15

fectly stable for nearly a month. There is always a slight precipitation with the concentrated solutions.

The next step in the improvement of this process was the use of a vacuum to accomplish the purpose served by the nitrogen gas, (Fig. 14). After the air is exhausted from the apparatus the retort is heated by means of a gas flame and the sulfur fumes drawn over into the soap and water solution and the process continued until a slight precipitate of sulfur is deposited on the bottom of the flask. The amount of sulfur that a glue or soap solution will take up was found to vary with the concentration of the dispersion medium. Preliminary experiments indicate that a 10% glue solution will take up approximately 1 per cent of its weight in sulfur.

Through the cooperation of Mr. R. C. Thompson, mechanical superintendent of the Boyce Thompson Institute, an apparatus was installed for making colloidal sulfur in barrel lots. The attached diagram, (Fig. 15) indicates the principal features of the mill. The retort (R) consists of an iron cylinder within a cylinder and surrounded by a lead bath. The sulfur is introduced into the retort by means of a pipe which is provided with a screw cap (C). The retort is heated by means of a gas burner (B), until the lead melts. The sulfur fumes escape through the vent (V) into the condensing chamber (CH). The dispersion medium is placed in a tank (T) which contains a coil (CL) of steam pipes so that the temperature of the solution may be regulated. When the iron retort exhibits a cherry red color the dispersion medium is allowed to enter the condensing chamber, and the escaping sulfur fumes are forced into the jet of water and soap, and colloidalized. The colloidal sulfur then flows through the outlet pipe (O). It requires about 45 minutes to make 50 gallons of colloidal sulfur with this apparatus. As the process is not continuous it is necessary for the retort to cool before adding the next batch of sulfur. The mill has a capacity of 150 gallons per day and costs about $75.00. By means of this mill it has been possible to disperse 16 lbs. of sulfur in 50 gallons of soap and water solution. With a slight change in the apparatus the process could be made continuous.

Field Tests—Through the cooperaion of the New York Agricultural Experiment Station, a comparative test was made of two colloidal sulfurs and two commercial preparations stated to contain colloidal sulfur. The experiments were conducted at Geneva, New York, for the control of apple insects and apple scab (*Venturia inaequalis*) in the season of 1924. The percentage of fruit showing insect and scab injury was made the standard of comparison. The trees sprayed were arranged

in four plats, all of which received lime-sulfur and arsenate of lead at standard strengths in the delayed dormant and pink periods. For the later applications each of the four plats received a colloidal sulfur and arsenate of lead (3 pounds to 50 gallons of spray solution). In the course of the season each plat received four applications of combined colloidal sulfur and arsenate of lead spray.

It will be noted in Table 7 that our preparation gave the best control of apple scab and somewhat better results than the other sprays for codling moth and leafroller. Plat IV of this series was sprayed with our colloidal sulfur No. 2, the stock solution of which contained sulfur at the rate of 12.5 pounds per 100 gallons of glue solution (10 pounds of glue to 100 gallons of water). Three gallons of the stock solution were diluted with water so as to make 50 gallons of spray solution. The cheapness and directness of manufacture combined with the ability to produce results which compare favorably with the best grades of colloidal sulfur now on the market should tend to give it a decided advantage over other preparations.

TABLE 7.—A COMPARATIVE TEST OF FOUR COLLOIDAL SULFUR PREPARATIONS ON APPLE

| Tree Number | Number apples per tree | Percentage apples injured by scab | Percentage apples injured by codling moth | Percentage apples injured by rosy aphis | Percentage apples injured by leafroller | Brand of Colloidal Sulfur |
|---|---|---|---|---|---|---|
| | | | *Plat I* | | | |
| 1 | 1184 | 7.85 | 14.18 | 41.97 | 0.42 | Proprietary Brand A. 12½ lbs. to 50 gals. |
| | | | *Plat II* | | | |
| 1 | 1921 | 77.87 | 6.55 | 49.50 | 0.26 | Brand B. 1 |
| 2 | 443 | 66.13 | 15.12 | 27.08 | 0.22 | to 200 or 1 |
| 3 | 1554 | 56.14 | 7.40 | 8.04 | 0.19 | qt. to 50 gals. |
| 4 | 2468 | 37.35 | 7.86 | 37.68 | 0.48 | |
| | | | *Plat III* | | | |
| 1 | 3313 | 8.87 | 5.64 | 46.18 | 0.21 | Proprietary Brand C 5 lbs. to 50 gals. |
| | | | *Plat IV* | | | |
| 1 | 614 | 1.79 | 4.07 | 47.88 | 0.16 | Hartzell & Lathrop (No. 2) 3 gals. to 50 gals. |
| 2 | 1968 | 7.01 | 5.38 | 40.09 | 0.05 | |

At this point Fourth Vice-President R. W. Harned took the Chair.

VICE-PRESIDENT R. W. HARNED: The next paper is by C. E. Hood.

# FISH OIL—AN EFFICIENT ADHESIVE IN ARSENATE OF LEAD SPRAYS, AND RESULTS WITH OTHER SUBSTANCES USED

By C. E. Hood, *Assistant Entomologist, U. S. Bureau of Entomology, Melrose Highlands, Mass.*

(Abridged copy.)

For a number of years many experiments and tests have been made with various substances, such as soap, glue, and molasses, in arsenate of lead and other spray solutions to increase their adhesive and spreading qualities.

As none of the above had proven satisfactory, the writer conducted experiments from 1921–1923 in a small way, and in 1924 on a large scale using high power sprayers, and covering large areas, these being located in Somerville, N. J. and Saugus, Mass., and a small area in Melrose Highlands, Mass.

In all of the plots 25 lbs. of powdered arsenate of lead was used to 400 gals. of water, except in the case of the lead oleate where the arsenate of lead and lead oleate were combined into a paste.

The materials used and the amount added to each 400 gal. tank of spray solution was as follows: Soap, 8 lbs.; Fish oil, 1 gal.; Linseed Oil, 1 gal.; Corn Oil, 1 gal.; Casein, 4 lbs.; Flour, 6 lbs.; Miscible Oil, 4 gals. in 1 plot and 2-2/3 gals., in the other. In the Lead Oleate plot, 50 lbs. of the material was added for each 400 gals. of spray.

All of these materials were applied to the foliage in the early part of June 1924 and during the summer, after each moderate to heavy rain, the trees were examined to note the amount of spray washed off and any injurious effects to the foliage. In Somerville, N. J., up to July 9 between 5 and 6 inches of rain had fallen, and up to September 17 almost 16 inches of rain, while at Saugus, Mass., up to July 15 about 2 inches of rain had fallen and on September 23 a total of almost 17 inches, and an estimation of the spray removed is given in the following table:

| Adhesive Used | New Jersey Plots | | | | Massachusetts Plots | |
|---|---|---|---|---|---|---|
| | Coniferous Growth | | Deciduous Growth | | Deciduous Growth | |
| | July 9 | Oct. 1 | July 9 | Sept. 17 | July 15 | Sept. 23 |
| Auto Soap | 90% | 95% | 90% | 95% | — | — |
| Lead Oleate | 70% | 90% | 75% | 90% | 60% | 85% |
| Flour | 70% | 80–90% | 80% | 90% | 65% | 80–90% |
| Casein | 60% | 85% | 50–60% | 75–80% | 50% | 80–85% |
| Corn Oil | 15–25% | 50% | 10–15% | 15–25% | 5–10% | 30% |
| Fish Oil | 10–15% | 40% | 5–10% | 20% | 5% | 25% |
| Linseed Oil | 5–10% | 30% | 5% | 15% | 5% | 20% |
| Miscible Oil | — | — | 50% | 60–65% | — | — |
| Arsenate of Lead | 75% | 80–90% | 65–75% | 80–85% | 60–65% | 80–90% |

The above table shows that the drying oils were superior to any of the other materials used. The miscible oil plot at Melrose Hlds., Mass.,

which was sprayed later than the preceding plots showed a wash of about 40% on July 15th and 60% on September 23.

### Conclusions

Of all the substances used, the drying oils were the most satisfactory. While linseed oil was slightly better than fish oil, the latter was selected as it is much cheaper.

As lead sprays containing fish oil not only adhere strongly to the foliage on the trees but also to the vegetation beneath the trees for a long time, livestock should not be allowed to graze beneath trees that have been sprayed with this solution as poisoning may result.

Fish Oil as an adhesive was used in arsenate of lead solutions only. It was not used in combination with Bordeaux mixture, nicotine sulphate, soap or any other ingredients.

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Mr. E. R. Van Leeuwen: I would like to ask Mr. Hood what method was used in determining the washing of the arsenical.

Mr. C. E. Hood: By comparing the foliage taken from the plots at each examination with the foliage collected in the plots shortly after application of the spray.

Vice-President R. W. Harned: The next paper is by C. H. Richardson.

## THE DIPYRIDYLS AS CONTACT INSECTICIDES

By C. H. Richardson, *U. S. Bureau of Entomology, Washington, D. C.*

Abstract

Dipyridyls are isomeric pyridine derivatives which bear certain resemblances to nicotine in chemical structure, physical properties and toxicity to insects. Crude dipyridyl oil, a mixture of several isomeric dipyridyls and impurities, was found to be highly toxic to 6 species of aphids when applied in spray form. In submergence tests with several species of coleopterous and lepidopterous insects, it also proved to be toxic. To the aphids it was not as toxic as nicotine, but to several of the larger insects it was more toxic. The toxicity of several of the isomers from the crude dipyridyl oil was ascertained; one of these appears to have marked toxicity. Concentrations of crude dipyridyl which are sufficient to kill aphids are apparently harmless to certain of the plants they attack.

(Withdrawn for publication elsewhere.)

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Mr. Geo. E. Sanders: I would like to ask Mr. Richardson what sort of free pure nicotine he used in checking his Dipyridyls. The reason I

ask is this: We have tested free nicotine, that is ninety per cent free and forty per cent nicotine sulphur, and it seems in the manufacture of ninety per cent free nicotine there is a conversion that takes place and the ninety per cent free nicotine is certainly not as toxic as nicotine sulphates. When checking against ninety per cent free nicotine, one is not checking against as good material as thirty per cent sulphate, according to our experience. I would like to know whether it is ninety per cent free nicotine that he used.

MR. C. H. RICHARDSON: The nicotine which we used in this investigation was prepared by ourselves from commercial nicotine sulphate. By adding an excess of lime and extracting with ether, then distilling off the excess of ether and finally distilling twice *in vacuo*, we obtained a practically colorless product. That was our standard nicotine: practically colorless and nearly odorless, which I believe is a fairly good indication of pure nicotine.

We made up our solutions from this and if we kept the solution any length of time we checked it up by the silicotungstic acid quantitative method. We have also checked nicotine sulphate against *Aphis rumicis* and have obtained a toxicity curve. We find there is practically very little difference between nicotine and nicotine sulphate when figured on the nicotine base content.

MR. WILLIAM MOORE: I would like to ask Mr. Richardson whether he has tested any of these compounds as to optical activity.

MR. C. H. RICHARDSON: We have not done that yet, Dr. Moore.

VICE-PRESIDENT R. W. HARNED: The next paper is by Mr. William Moore.

## ELECTRIC-CHARGES OF ARSENICAL PARTICLES

By WILLIAM MOORE, *Chief Entomologist, American Cyanamid Co., New York*

ABSTRACT

The common arsenical insecticides may be so manufactured that they will contain an adsorbed positive ion. Such insecticides show great adherence to plants, resisting the washing effects of rain and dew.

It is also possible to impart an electrostatic charge to the insecticide particle at the time of dusting. This aids in the distribution of the insecticide over the plant.

The present paper is a brief discussion of these two factors.

In 1921 the author presented a new theory covering the adherence of arsenical particles to the surface of leaves. It was pointed out that the common arsenicals when suspended in water and placed in the electric field either migrated, to a slight extent, toward the positive pole, or failed to migrate at all. These tests indicated that the common com-

mercial arsenicals were, when wet, either neutral or carried a negative electric charge.

It is well known that filter paper made of cellulose reacts negatively when wet. The reaction of the epidermis of various leaves to stains indicated that leaves react as a negative ion. A study of the movement of water across or through a leaf surface placed in the electric field showed that the surface of the leaf is electrically negative.

Arsenicals of lead, zinc, copper, iron, aluminum, chromium, barium, magnesium, and calcium, were prepared in such manner that, when suspended in water and placed in an electric field, they migrated toward the negative pole and, therefore, carried a positive charge of electricity. These positive arsenicals showed great adherence to the surface of leaves, resisting the action of rains and dews.

Recently several workers have found that, when arsenical dusts are blown out of a duster with considerable force, the particles of dust become charged with static electricity. Under such conditions, the dust particles are well distributed over the plant surface, being attracted by their electrostatic charges.

Confusion has arisen concerning these two different electric phenomena and it is hoped that the following discussion may clear up this confusion.

## Electric Charges Carried By Ions

When a salt is dissolved in water, ions are formed consisting of an atom or group of atoms. Upon placing such a solution in an electric field these ions migrate toward one or the other electrodes. These ions which migrate toward the positive pole carry negative electricity and are said to be negatively charged, while those which migrate toward the negative pole are positively charged. Some ions carry more than one charge. Sodium ions carry one positive charge, chlorine ions one negative, calcium ions two positives, and sulphate ions two negatives.

Ions vary in size, some being so large, as in the case of certain dyes, that they reach colloidal dimensions and are known as positive or negative colloids. Glass is a silicate which still retains some sodium or potassium ions. When the glass is wet with water these ions pass into the water making it positive, due to the positive sodium or potassium ions and the glass becomes negative due to the negative silicate ion. A solution of a negative colloidal dye will not leave on glass a deposit of its particles which is at all difficult to wash away. A positive colloidal dye will leave a film of its particles which is extremely resistant to the washing

action of water. This phenomenon is similar to the adherence of positive arsenical particles to the negative leaf surface.

### Positive Arsenicals

Arsenical insecticides are made from positive metallic ions and negative arsenite and arsenate ions. Ordinarily, the proportions are such that the precipitated arsenical is electrically neutral. Under proper conditions the arsenical may be so made that there will be a slight excess of the metal present as an ion adsorbed on the arsenical. When wet with dew or with rain, the positive charge of the arsenical holds it to the negative leaf surface. Recent tests of such a positively charged calcium arsenate indicated that the adherence of the dust measured by its resistance to the washing effect of rain and dew was 250% greater than ordinary calcium arsenate dust. The value of this dust to the cotton grower is at once apparent.

### Static Electric Charges Produced By Friction

Electrostatic charges caused by friction are quite different from the charges present when the particles are wet and due to the presence of ions as described above. When glass is electrified by friction it may be positive or negative. A glass rod rubbed with silk becomes positive, but when rubbed with fur, it becomes negative. A glass rod charged with either positive or negative electricity may be used to pick up a small piece of paper. The piece of paper is neutral but, as the charged rod is brought close to it, the rod induces in the paper an opposite charge on the near side and a similar charge on the far side. Lines of force are thus set up connecting the rod and the piece of paper and it is the resultant of the pulls of all these lines which causes the filter paper to be attracted to the rod.

When arsenical dust particles acquire an electrostatic charge, due to the friction of dusting, they react similarly to the electrified glass rod. The charge may be positive or negative. The leaf not having been subjected to friction, plays the part of the piece of paper. The approach of the charged arsenical dust particles induces the charges in the leaf, thus establishing the lines of force which pull the two objects together. The only difference in the two experiments is that the piece of paper being free to move is drawn to the glass rod, while in the other case the arsenical dust particles are free to move and are drawn to the leaf.

The static charges aid in the distribution of the particles of dust over the surface of the leaves and cause the dust particles to be attracted to the leaves. This result would be obtained whether the dust particles

carried positive or negative electrostatic charges produced by friction. The presence of such an electrostatic charge would not increase the resistance of the dust to the washing effect of rains or dews, since a charge produced by friction has no influence on the charge exhibited by a particle when wet. On the other hand, it is quite conceivable that an arsenical which has a positive charge when wet, due to an adsorbed ion, might carry a negative electrostatic charge at the time of dusting, due to the friction of the dusting operation. The two phenomena are independent.

## Summary

The common arsenicals, as now manufactured, suspended in water and tested in an electric field, exhibit a negative or no electric charge. These arsenicals show no great resistance to the washing effects of rains or dews.

The common arsenicals may be manufactured in such manner that they exhibit a positive electric charge when wet with rain or dew, due to the presence of an adsorbed positive ion. These arsenicals will show great adherence to the negative leaf surface resisting the action of rains or dews.

The common arsenicals may acquire a positive or negative static electric charge by the friction at the time of dusting. Such a charge will aid in the distribution of the dust particles over the surface of the plant but will not materially prevent the particles from being washed away by the action of dews and rains.

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Mr. George I. Reeves: I will take a moment to present the other side of the picture, the electrostatic charge of dust particles, which, as Dr. Moore has said, is a totally different thing from the ionization charge, and I will simply state a few facts which have not been made public.

All dusts when they leave the blower are electrified. Those which I have tested are zinc arsenite, calcium arsenate, lead arsenate, Paris green, hydrated lime, silica and sulphur. Evidently the electric charge arises from friction between the dust and the metal of the blower, since it is present both in gear-driven machines where there is no friction from belts and also in homogeneous dusts where friction between different kinds of dust particles does not take place.

The most striking consequence of this electric charge is a large and exhilarating spark which you notice if you touch the machine while it is

running, but the most important consequence is the attraction exhibited by these electrified dusts for the foliage of plants, which being grounded conductors, are neutral.

While all dusts are electrified at the moment of leaving the machine, they act differently afterward. Zinc arsenite, Paris green, sulphur and silica, being non-conductors, cannot be discharged at once by a single contact; although they lose the charge residing at the point of contact, they retain that of the rest of the surface and therefore continue to be attracted to the plant and to neutral dust particles. If the non-conducting dust is poisonous it is an effective insecticide, or if it is non-poisonous it may render poisons of the other class effective.

The conducting dusts, on the contrary, discharge completely upon contact with a grounded conductor, and lose their attraction. The poisonous conductors, calcium arsenate and lead arsenate, are useless in alfalfa weevil control unless they are mixed with non-conducting fillers, and the non-poisonous conducting dusts, as hydrated lime, are useless as fillers for the poisons of the same class.

Certain conclusions can be drawn from these facts. An arsenical dust, to be effective, must contain an electrifiable (charge-retaining) ingredient; it must be subject to sufficient friction to produce an electric charge in the course of application, and it should be applied when the air is dry, without much attention to light winds.

Neglect of these points explains most of the failures and erratic results from the use of arsenical dusts. Moisture may be useful in sticking the arsenical to the plant, but it is not necessary. If the air is dry, the electric charge does the work and renders the operation independent of the wind, up to the point where the dust becomes entirely uncontrollable. I have dusted with excellent results throughout the middle of a hot, dry day, with the wind blowing 12 miles an hour.

In the climate where I have been working these things mean a revolution in insecticidal procedure. Some crops would never be sprayed if it were possible to dust them. The advantages of dusting are obvious, and I think that now we are in a position to add to these advantages the essential one of certainty. Furthermore, the principle of electrostatic attraction of particles promises to be useful in many industries besides insecticidal dusting, and to place the study of frictional electricity on a level with that of voltaic and induced currents, which has run away from it in recent years.

VICE-PRESIDENT R. W. HARNED: The next paper is by J. G. Sanders.

# MISCIBLE OILS AND OIL EMULSIONS

By J. G. SANDERS, *Philadelphia, Pa.*

ABSTRACT

Oil sprays in emulsion form are gaining prominence throughout the United States. Attention is called to the indefinite nature of recommendations for the preparation of homemade emulsions. "Red engine oil" as recommended is too indefinite, since hundreds of specifications for these oils are possible with tremendous variation in viscosity, base, gravity, cold test and color. Pale or yellow oils would serve as readily for emulsions. Although paraffine oil has been specifically recommended, asphalt base oils lend themselves more readily to emulsification. The variability of water content and base of fish oil soaps is discussed along with the variations in saponification value. Experiences in several states have shown that recommendations for home prepared emulsions should take into consideration the character and type of soaps used as well as the types of water locally available. Until some careful tests are made with oils of varying types and viscosities, no specification for the oil most desirable for homemade emulsions can be offered.

Oil sprays in emulsion form are gaining favorable prominence and are being recommended rather widely throughout the United States and several other countries. It was thought that a brief discussion of oils would be helpful to entomologists and others who are concerned with the use of oil in emulsion form, although in so brief a space little more than a few suggestions can be given consideration.

Association with an oil company which manufactures a wide range of petroleum products has been the writer's privilege for the past year and a half. This brief time has offered certain opportunities for gaining some knowledge of oils and the many other petroleum products. The amazing number of types of crude oils as they flow or are pumped from the ground or are extracted from shales and the several refining methods used to produce a long list of products which vary from the lightest benzine to the ultimate contents of an oil still which may be styled road tar or asphalt, have served to surprise the writer.

Almost co-incident with the publication of a federal bulletin on methods of preparation of oil emulsions, a number of states adopted these recommendations and heartily advocated the home preparation of emulsions through their extension departments and by bulletins and by various other means; and just here I wish to insert a bit of criticism concerning the recommendations of the past two or three years. Too often we have found inexperienced lecturers travelling over their states and even into other states advising growers how to prepare oil emulsions. In many cases they told only the "rosy" or bright side of the story and failed to mention, or at least, to impress their hearers with the possible difficulties that might be encountered; consequently there were

many disappointments and failures throughout the country and no little injury has been caused by imperfect emulsions while not infrequently imperfect pest control has resulted. The originally recommended 2% emulsions advocated to provide an extremely cheap spray have given way to 3% and 4% emulsions, in order that better control might be effected under average orchard conditions.

First of all, let us take up the formula for the preparation of stock oil emulsion which called for certain proportions of "red engine oil," fish-oil soap and water.

What is "red engine oil?" Several hundred different specifications might be offered for "red engine oil" on account of the tremendous variations in viscosity, in gravity, flash point, fire point, cold test, color and base, whether of asphaltic or paraffine type or variable combinations of both. The term "red engine oil" means about as much to an oil company as an undescribed, unlisted bond on the market, and affords an oil company great latitude in filling an order, because in a ten barrel order several types of red oils might be included. On the other hand there are numerous pale or yellow oils that would serve fully as well as the red oils, as the resulting color is largely a matter of refining methods and the origin of the crude oil. Generally speaking, the crude oil, in the Pennsylvania-Ohio district is of paraffine base, that from the west coast, asphalt base; and in the Oklahoma-Texas region, variable combinations of both; likewise the characteristics of the crude oil may vary from a light colored readily flowing material to an extremely thick black form which can be pumped only with difficulty. From these many types of crude oils, with varying methods, are distilled and produced a wide range of petroleum products with tremendous variations in the percentage of possible extractions from each of these different types.

Curiously in many of our bulletins on homemade emulsions, paraffine oil is specified and in the Federal formula "Diamond paraffine" and "Junior Red" are recommended although these are merely trade names of products of a single company, a practice rather contrary to Federal regulations. It is well known among oil men that asphalt base oils lend themselves more readily to processes of emulsification. The distinct recommendation of paraffine oils referred to above has in some instances caused growers in Oklahoma and Texas to send east to secure a Pennsylvania or Ohio paraffine oil when better oils for emulsification purposes were to be had in their own states.

Paraffine base oils and asphalt base oils differ in many respects, the most marked being the almost total absence of paraffine wax in the

latter, while as much as twelve or even higher percentages of paraffine wax may be recovered from the former type. It is well known that paraffine "sets" or congeals, and conversely melts, at rather high temperatures and in lubricating oils made from a paraffine crude, the extent to which the paraffine wax is drawn off in distilling determines what is known technically as the "cold test" or the temperature at which the oil begins to "set" or solidify. Some of these paraffine oils have a cold test as high as 85° while many range between 35–60°.

In the preparation of homemade emulsions, heating oil with soap and water must precede the emulsifying process usually carried out by force pumping at least two or three times over. As the material is pumped over, it naturally cools rapidly, particularly under outdoor conditions and this cooling is considered one of the variable factors which interferes with uniform success in making the stock emulsion.

Viscosity is a property common to all liquids in greater or less degree and is entirely independent of specific gravity, hence this latter factor may be very largely eliminated in the consideration of spray oils. As an example of viscosity, glycerine has a specific gravity of 1.26 and is vastly more viscous than mercury with a specific gravity of 13.5. We may have an oil of the lubricating type with a viscosity of 750 at 100 degrees and 135 at 210°, the viscosity having changed tremendously within a range of a little more than a 100°. On the other hand we may have an oil with a viscosity of 250 at 100 and of probably around 125 at 210°, the change here being very much less. Certain lubricating oils have such high viscosity that they are almost as sticky as the compound on fly paper.

Certain types of insects or insect eggs, it would seem from records, are more readily killed with an oil of rather low viscosity, which quickly penetrates and which carries a proportion of the lighter fractions. The eggs of the fruit tree leaf roller on account of their method of attachment on the twigs and the varnish like protective covering, apparently are more readily controlled with the lighter oils, whereas the eggs of the European red mite and eggs of aphis are more thoroughly controlled with a high viscosity oil.

The federal formula calls for potash whale oil or fish oil soap. Here again we find tremendous variation in the quality of soaps on the market as to potash or soda content and percentage of water included, all of which greatly affect their saponification value. The marine oils secured from various fish or whales contain fatty acids and glycerides in varying degrees. In the presence of water and suitable temperature, fatty oils

decompose more or less rapidly forming fatty acids and glycerides. To the soap manufacturer, the fatty acids are all-important and are united with an alkali to form soaps, the glycerides in various proportions being left, which may or may not be removed, thus causing great variability in soaps of both soda and potash base. It is generally known that the soda soaps are more or less solid while the potassium soaps are soft in type, whereas a combination of the two may have all the intergrades with varying water contents and saponification value.

The third ingredient which goes to make up an emulsion, water, has tremendous variation in so-called hardness. It is always advised that rain water or soft water be used in preparing the stock emulsions, but difficulty frequently arises when it becomes necessary to dilute the stock emulsion with the available water supply for orchard spraying and the inability to secure sufficiently soft water for this purpose has resulted in many disappointments and losses which have come under observation during the past year. We recall one instance of a large grower in a nearby state who purchased twenty-four barrels of the emulsion commercially prepared according to the government formula, which had to be discarded or returned because it would not mix with the hard limestone water of his region. Having depended on this oil up to the last week before spraying time, he was unable to supply himself with other materials and suffered a considerable loss.

A large grower in an eastern state purchased ten barrels of "red engine oil" from Baltimore, five barrels of which were practically non-emulsifiable with his methods while three barrels gave very good emulsion and two, only moderate results, although all of them were treated alike and by a grower of many years experience and experiment station training. It is quite evident that several of these barrels of oil were of a type unsuitable for emulsion by the recommended method. These are but two instances of many similar cases in various parts of the country which have come to notice.

In consideration of the fact that there are hundreds of types of so-called engine oils of red, brown or pale color and with viscosities ranging from 70 at 100 degrees to above 2,500, and with cold tests varying from 85 degrees down to 20 and 30 below zero, and in consideration of the variations in soap compounds and water available, it is believed that greater caution should be observed in recommending the home preparation of oil emulsions. This is not a brief, necessarily for the commercially emulsified oils because many of the oil companies who have prepared oils also sell the ingredients for the home emulsified oils, but it is

more in the nature of caution lest injury may result to such an extent that the growers will become fearful about the continued use of the much more effective oil emulsion sprays.

A lesson to be learned from these difficulties and failures is that due regard should be given by those recommending the home preparation of emulsions to the available water supply and the character and type of the soap used as well as the types of oil. Some of our entomologists and horticulturists are wisely adhering to the principal that in certain parts of our country at least the commercially prepared emulsions or miscible oils made under the supervision of oil chemists are to be preferred and recommended, and in many incidents the wisdom of these recommendations has been apparent.

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MR. E. P. FELT: I would like to ask the speaker if there is any place where a mere entomologist, we will say, can get something which is reasonably standard in regard to these various oils. That is, the speaker has been telling us about the difficulties. We knew them to a certain extent. Now, is there any way that we can go into the market and buy and continue to purchase an oil of any known standard?

MR. J. G. SANDERS: It is possible to secure uniform types of oil if some of the experimenters will determine the viscosity and the type of oil best suited for certain types of emulsions, for certain types of insects or certain types of spraying, and then specify exactly what is wanted. As I said, there are thousands of grades of oils.

MR. E. P. FELT: It is not only a question of viscosity; it is a question of base too, isn't it?

MR. J. G. SANDERS: I am an entomologist and I myself two years ago didn't know a great deal about oil and I figured there were a great many people here in the same frame of mind. I presented this paper this afternoon just for the purpose of acquainting you with the tremendous variations in oils. It is positively startling. When I hear, as I have heard at the meetings here several times, the words "Red Engine Oil" used, it doesn't mean a thing to me. The officials of my own company came to me and asked, "What do they mean by this Red Engine Oil?" We have a hundred kinds of such oil.

A little hint I want to leave with you, and those who experiment in the future with the home prepared oils,—determine first what is the viscosity and the base and the cold test of your oil so that when you get a report it can be understood.

MR. E. P. FELT: Here is a "hint" on the other side: Shouldn't the oil companies be able to provide standard oils which will measure up to reasonable tests so far as insecticide work is concerned? They have the product to sell and the agricultural public is in the market to buy the material for a certain purpose.

MR. J. G. SANDERS: In reply to that I would say that the oil companies would be glad to furnish oils according to any specification, as they do for hundreds of different users. Our own company furnishes oil for use in refrigerating machines which run way down below zero up to oils that solidify at eighty-five and ninety degrees Fahrenheit.

But the point I want to make is that when you or your constituents order a "Red Engine Oil," it affords too much latitude to an oil company to give anything they have in stock, which apparently happened in the case of the purchaser from the Baltimore firm as mentioned in my paper.

VICE-PRESIDENT R. W. HARNED: The next paper is by Messrs. Siegler and Popenoe.

## THE FATTY ACIDS AS CONTACT INSECTICIDES[1]

By E. H. SIEGLER and C. H. POPENOE, *Associate Entomologists, Bureau of Entomology, United States Department of Agriculture*

ABSTRACT

An investigation of the aliphatic fatty acids has shown that certain members of the series possess promising insecticidal properties as contact sprays. The studies have indicated that the toxicity of soaps when used as contact sprays is due to the release of the acid components through hydrolytic dissociation.

For more than a century the compounds commonly known as soaps have held a foremost place in the control of many of our destructive insect pests. Practically non-toxic to higher animals, convenient, low in cost, and readily and safely applied by inexperienced operators, they have gone far to satisfy the demand for a popular contact insecticide. In general, they are applicable to a variety of pests, plants and conditions, affording excellent spreading power, good toxicity, fair compatibility with other insecticides, and often serving as a basis whereby the effectiveness of other spray materials may be increasd, by readily imparting their qualities to such mixtures.

The toxicity of soaps to insects has been attributed to various factors, among which mechanical occlusion of the body openings and the caustic properties of the alkaline constituents have apparently received the chief support of investigators. The conclusions reached after a season's

[1]Patent applied for by authors.

work, based on the conception that the fatty acids are chiefly responsible for the killing power of soaps, are herewith presented for the consideration of the meeting.

Chemically, soaps are defined as the alkali salts of the fatty acids, and this definition may be strictly confined, from an insecticidal standpoint, to the salts of the long-chain members of that series. Their interesting chemical properties include that of partial hydrolysis in water solutions, resulting in the presence in such solutions of free alkali and free fatty acids. Under these conditions, a variable proportion of the fatty acids thus freed then tend to unite with the fatty acid radical of the unhydrolyzed portions, assuming a colloidal form, or "sol." The extent to which this action takes place varies with the dilution, reaching a maximum in relatively strong and in relatively weak solutions, while at a more or less variable median a maximum amount of free fatty acids in the crystalloid form is available.(1) This characteristic goes far to explain the frequent observation that an increase in concentration of a soap solution so often fails to increase toxicity to a corresponding degree.

The hydrolysis of a soap solution on the addition of water is by far less complete than has commonly been believed. Recent experiments(2) have shown that in the case of soaps in common use those prepared from the lower fatty acids yielded a greater proportion of free fatty acids under optimum conditions than did those containing the longer-chain radical. The greatest proportion of free acid was encountered in the soaps containing a high percentage of lauric acid, although in no case did this exceed six per cent. Under less favorable conditions the proportion of free acid was more than correspondingly reduced, while the prevalence of the colloidal form was increased.

The extent of hydrolysis and the formation of the acid-soap combination in a hydrolyzed soap solution is also greatly influenced by the presence in the solution of certain solvents, such as the hydrocarbon oils, benzene and toluene.(3) Although the hydrolysis never becomes complete, it may be of interest to observe that if benzene is added to a warm soap solution and well shaken with it during titration, nearly the whole of the alkali can be determined by standard acid with phenolphthalein as indicator. Approximately 70 per cent of palmitic and oleic acids in solutions of 1 gram of their sodium soaps to 700 cc. of water, may be extracted with benzene. It is thus apparent that hydrolysis is favored by the removal of one of the hydrolysis products.

It is manifest that the properties above indicated have a decided

bearing on the efficiency of soaps as insecticides. If the mechanical obstruction of the body openings or the action of the free alkali is responsible for the toxicity of soaps, an increase in toxicity should be obtained by every increase in concentration. On the other hand, if the free fatty acids are the toxic agents, and these are dependent for their action upon absorption through the insect membranes, the familiar characteristics of insecticidal soap solutions might be expected to assert themselves. That the latter hypothesis tends better to explain insecticidal action in soaps is the belief of the writers.

Although soaps are cheap and readily obtainable, their employment as insecticides is, for the reasons indicated above, of doubtful expediency. Only a small percentage of the fatty acids entering into their composition is available for toxic purposes, and, of this percentage, slight variation in the preparation of the mixtures may easily result in considerable differences in toxicity, particularly as commercial soaps contain variable percentages of several distinct fatty acids. A high proportion of the colloidal forms of the fatty acids would necessarily predicate a reduced efficiency from the insecticidal standpoint, since the semipermeable insect membranes would permit only a very slow absorption of the toxic principles. Conversely, if the free acids were used the insect membranes would be readily permeable, and toxicity might be expected to reach a maximum per unit of fatty acid employed. That this is the case has been borne out by the results considered later in this paper.

The common employment of soaps is further complicated by the fact that different sections of the country demand and receive soaps varying materially in composition and characteristics. It stands to reason that correspondingly variable results may be expected even in the case of uniform practice, while when the personal equation is considered it is somewhat remarkable that the usual fairly satisfactory results are attained.

The fatty acids which, from their prevalence in nature, lend themselves most commonly to soap production belong to the saturated straight-chain monocarboxylic group and to the even-carbon members of that series. This group does not, however, include such acids as enter into the composition of some of the commoner insecticidal soaps, such as those prepared from fish and whale oils. The acids in the above mentioned oils are to a great extent (70 per cent or more) members of the various highly unsaturated series, difficult of separation and, aside from oleic acid, not commercially available as such. The tests outlined

in this paper were accordingly confined to the normal, or straight-chain, saturated monocarboxylic acids of the acetic acid series. The following homologues of the series were available: acetic, propionic, butyric, valeric, caproic, oenanthylic, caprylic, pelargonic, capric, lauric, myristic, palmitic and stearic acids. Where possible, the highly purified grades were used, although the techincal grades were employed when necessary. Propionic, valeric, oenanthylic and pelargonic acids were included for comparison with the even-carbon members of the series.

In conformity with their behavior as hydrolyzed salts, the fatty acids alone in colloidal emulsions show a spreading power indicative of low surface tension, and of a low interfacial tension when applied to leaves or to the insect body. When applied in the form of emulsion to either insects or foliage they readily and completely wet either waxy or polished surfaces and spread quickly over hairy caterpillars. Cabbage and nasturtium leaves are easily and completely coated.

The lower fatty acids show no serious toxicity to insects when used in practicable dilutions. As the molecule becomes heavier, however, toxicity increases. Practical toxicity was shown by caproic acid. The next higher homologue, caprylic acid, killed more than 90 per cent of the black chrysanthemum aphis at dilutions of 1 part to 500 of water, the toxicity decreasing only slightly when the dilution was increased to 1 to 1000. Capric acid, the next even-chain acid, killed more than 99 per cent of the green apple aphis at a dilution of 1 part to 1200 of water. Lauric acid at the same dilution was fatal to 96 per cent of the same aphis, while myristic acid proved considerably less effective.

Nonoic acid, the only odd-carbon acid among those tested giving a satisfactory kill, showed a toxicity equal at least to that of lauric acid, indicating that fatty acids containing an odd number of carbon atoms do not thereby lose in toxicity. Practically all of the tests upon which our conclusions are based were conducted on a laboratory scale in an outdoor insectary, with the use of a small atomizer drawing from the bottom of the chamber. Throughout the experimental work parallel tests, using a commercial 40 per cent nicotine sulphate solution in combination with soap, were conducted for comparison, and ample check material was kept under observation.

The principal subjects treated have been the rosy apple aphis, *Anuraphis roseus* Baker, the green apple aphis, *Aphis pomi* DeGeer, the bean aphis, *Aphis rumicis* Linn., the black chrysanthemum aphis, *Anuraphis sanborni* Gill., the black cherry aphis, *Myzus cerasi* Fab., and the aster aphis *Macrosiphum rudbeckiae* Fitch. The fatty acids are, however, toxic to insects of other orders, as well as to acarina.

Although the action of the fatty acids on the insect organism has not yet been determined, the rapid and complete paralysis which ensues upon their application to aphids indicates that they possess a specific toxic influence. It was noted in tests upon the black chrysanthemum aphis, in comparison with commerical 40 per cent nicotine sulphate solution, that in the case of the latter poison the mortality was indicated by the large percentage of dead aphids which dropped from the sprayed plants in the course of 24 hours. In the case of the plants sprayed with the fatty acids the dead insects remained attached by their inserted beaks, affording no index of toxicity such as was shown by the nicotine until the actual counts were made .

In the higher animals, soaps and fatty acids are known to be highly toxic when injected into the circulation, exerting a profound hemolytic action. (4) The salts of higher fatty acids above capric are hemolytic, while those from caproic down are not, nonoic acid salts being the turning point. (5) The marked power of some soaps and fatty acids to inhibit proteolytic enzymes (6) could hardly account for the immediate paralysis occurring in aphids subjected to their action. The hypothesis that the fatty acids in a crystalloid state penetrate the insect body walls and tracheae, thus gaining immediate hemolytic action on the hemolymph and body cells, seems more tenable. It is well known that the action of some of the most quickly toxic substances upon the higher animals depends upon this principle.

Plants show a varying susceptibility to injury by the acids of this chemical series. The foliage of the apple is not affected when sprayed with strengths toxic to apple aphids. No injury to chrysanthemum plants was shown by dilutions fatal to the black chrysanthemum aphis. On the other hand, the foliage of nasturtium was injured by the dilutions in general required to kill the bean aphis, and, more than any other tested, appeared susceptible to burning.

Numerous comparative tests of the free fatty acids, emulsified with distilled water by means of a colloid mill, with soaps, with glue and gelatine, with miscible oils and oil emulsions, and with dust diluents, were made during the past summer. Potassium, sodium and ammonium soaps were also prepared and tested, using both acid, neutral and alkaline preparations. In every case the free acids, emulsified with inert collodial or other suitable vehicles, showed much greater killing power than when combined as salts of the alkali metals. Even the acid soaps required several times the concentration found effective with the free acids to produce a satisfactory kill, although a mixture of approximately

equal parts of benzol and high test gasoline was added to increase hydrolysis. In the latter part of the season a standard solution of granulated glue, of such density as to contain approximately ¼ gram to the liter of spray mixture, was adopted tentatively as an emulsifier and to the present has proved satisfactory.

Tests looking toward the practical application of the insecticidal properties shown by preliminary work with the long-chain fatty acids resulted in the selection of a crude lauric acid commercially known as "double distilled coconut fatty acids" as embodying in the greatest degree the desirable features of those members of the series approximating the peak of practicable toxicity. A typical sample of this product, largely used in soap manufacture and otherwise industrially, was fractionated[2] with the following results:

| | | Per cent |
|---|---|---|
| A. | Fraction mostly caprylic acid (small amounts caproic and capric) | 4.0 |
| B. | Fraction mostly capric acid (small amounts caprylic and lauric) | 14.6 |
| C. | Fraction mostly lauric acid (small amounts capric and myristic) | 51.1 |
| D. | Fraction mostly myristic acid (small amounts lauric and palmitic) | 14.1 |
| E. | Fraction mostly palmitic acid (small amounts myristic, oleic and stearic) | 8.3 |
| F. | Fraction mostly oleic and stearic acids (small amount palmitic) | 5.6 |
| | | 97.7 |

The fractions A to D were individually tested for contact toxicity, fraction B, containing mostly capric acid, showing slightly greater toxicity than either A, C or D. This tends to confirm the theory that the peak of toxicity lies near capric acid $C_9H_{19}COOH$.

The presence of the lower fatty acids which enter into the composition of the double-distilled coconut fatty acid product render it for this reason perhaps more desirable as the toxic ingredient of an insecticide than any other. Not only do these lower acids themselves appear to exert the greatest toxicity, but they require, owing to their relatively low molecular weight, a much larger amount of alkali to saponify them, and consequently to reduce their efficiency. Their lime salts are comparatively soluble in water, and the soaps which they form are the most soluble in saline solutions of the useful series. It is therefore evident that a product based upon these properties will be suitable for the most diverse conditions likely to be encountered in its application to insecticidal purposes.

The commercial product selected is liquid at usual summer temperatures, (m.p. 27°C.), highly toxic even when greatly diluted, stable

[2]Bureau of Chemistry (Insecticide Laboratory), U. S. Department of Agriculture.

with miscible oils and oil emulsions, although, like soap, incompatible with lime-sulphur and Bordeaux mixture, readily obtainable in quantity, and at the time of writing is much lower in price than is nicotine. Difficulties in the preparation of a stock solution and the retention of the insoluble acids in a stable emulsion have been met by the addition of an equal amount of benzol gasoline to the commercial fatty acids, afterward using powdered glue as a colloidal stabilizer. The gasoline lowers the melting point to 5° C., thus serving to prevent solidification through lowered temperatures of the acid globules in the emulsion, also facilitating even distribution, while the glue greatly retards separation after emulsification. The stock emulsion given below has been tentatively adopted as a practicable basis for further tests. In series of tests with this formula, used in the proportions of 1 part of the coconut fatty acids to from 800 to 1200 parts of water, a mortality rate of from 94 per cent to 98 per cent has been attained against the green apple aphis, equivalent to the rates obtained with commercial 40 per cent nicotine sulphate in parallel tests at the same dilutions.

STOCK SOLUTION

| | |
|---|---|
| Coconut fatty acids (double distilled) | 200 cc. |
| Gasoline (benzol) | 200 cc. |
| Glue (granular) | 100 grams |
| Water | 525 cc. |

When made up as above, approximately a liter of stock solution is obtained, each 5 cc. containing 1 cc. of the commercial mixture of acids. Upon thorough shaking it readily becomes a milky emulsion capable of dilution by any ordinary proportion of water, and when so diluted it remains sufficiently stable for practical application. The fatty acid emulsions are incompatible with lime-sulphur or with Bordeaux mixture. The spreading power of the emulsion is excellent, toxicity high and cost of material extremely low. Prepared by this formula, coconut fatty acids have, in many of the experiments so far conducted, compared favorably, pound for pound, with commercial 40 per cent nicotine sulphate preparations in efficiency, and at less than one-fourth the cost per gallon of spray mixture.

In the use of this material care should be taken that the insects are thoroughly wetted, as its volatility is so low that its vapor alone cannot be depended upon to afford a toxic dosage. For this reason it is believed that high pressure and a drenching spray will afford the most effective results under field conditions.

This paper is intended only to present in a general way the results of a single season's work based on the theories and experiences outlined

in the fore part of the paper. For this reason detailed tables of the preliminary experimental evidence available are omitted. It is not the intent of the writers to recommend the use of the fatty acids at the present time, but it is felt that they may first come into use in apple spraying in conjunction with oil emulsions during the delayed dormant treatment for the simultaneous control of scale and apple aphids.

BIBLIOGRAPHY

1. McBAIN and SALMON, Proc. Royal Soc., 1920, (97), pp. 44–65, *also* McBAIN, TAYLOR and LAING, Chem. Soc. Trans., 1922, (121), pp. 621–33.
2. McBAIN and MARTIN, Chem. Soc. Trans., 1914, (105), pp. 957–77.
3. REYCHLER, Jour. Soc. Chem. Indt., 1912, p. 1189.
4. FAUST, Suppl. Bd., Schmiedeberg's Arch., 1908, p. 171.
5. SHIMAZONO, Z. Immunitat., Ref., 1911 (4), 656.
6. JOBLING and PETERSON, Jour. Exp. Med., 1914 (19), 251.

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MR. WILLIAM MOORE: I might raise the question as to whether the fatty acids they used were all dissolved in basic sodium carbonate.

MR. E. H. SIEGLER: No, they were not.

VICE-PRESIDENT R. W. HARNED: The next paper is by A. C. Morgan and R. G. Mewborne.

## THE DISTRIBUTION OF AN INSECTICIDE MADE VISIBLE

By A. C. MORGAN, *Associate Entomologist* and R. G. MEWBORNE, *Field Assistant*, *Bureau of Entomology, U. S. Department of Agriculture*

ABSTRACT

A mixture of phenolphthalein and arsenate of lead was dusted on tobacco. A print of the leaves was taken on filter paper impregnated with an aqueous solution of sodium hydrate.

How thoroughly an insecticide distributes through a plant under varying conditions of application has long been a matter of guess work or determinable only by the slow and laborious methods of analysis. The present method offers an easy and immediate determination to the entomologist and layman who may not have available the services of a chemist. The method is applicable to all dusts of whatever character and also to sprays.

Uniformity of application of definite quantities of an insecticide is essential in all control experiments. The thoroughness of the distribution on individual plants, on different leaves of the same plant and upon specific areas of the same leaf has hitherto been largely a matter of conjecture, or determinable only by analytical methods.

The method herein presented offers to the entomologist and layman an easy and rather simple means of making such determinations. It consists primarily, in the use of an indicator thoroughly mixed with the

dust or spray and the rendering of this indicator visible upon a suitably prepared paper imprint of the treated surface. The method in detail is as follows:

REAGENTS:

Phenolphthalein

Sodium Hydrate

Alcohol

Developing Paper—Filter paper impregnated with 1½ times its weight of a 5% aqueous solution of Sodium Hydrate. The filter paper must be uniformly impregnated, and we have found, by sprinkling the top sheet of each lot of five papers with the proper amount of the alkaline solution and bulking a number of lots for several hours in the humidor, that thorough distribution was obtained and maintained.

APPARATUS:

Press—Two flat surfaces, one with a graduated slot to accommodate the midrib of the tobacco leaf.

Paper—Ordinary paper for separating the developing paper from the cotton.

Cotton—Ordinary cotton batting, 1 to 2 inches in thickness; must be comparatively uniform.

Drying Oven—With slotted or perforated shelf. The oven must be heated sufficiently to dry the prints in from 1 to 2 minutes.

METHOD:

Dust—Mix one part (more or less) phenolphthalein with 4 parts of insecticide.

Spray—Dissolve ¼ pound phenolphthalein in alcohol and mix with 50 gallons of spray solution.

Procedure—On the slotted half of the press is placed a layer of cotton, then a sheet of ordinary paper. Carefully place the leaf thereon, taking care that the midrib is in position over the slotted area so that contact of the whole surface of the leaf with the developing paper may be assured. A sheet of developing paper is now carefully laid on the leaf, followed by a sheet of ordinary paper and then a layer of cotton. The top half of the press is now placed in position and pressure of about 300 pounds applied for 1 minute. The imprint paper, which is now developed, is carefully removed to the oven and quickly dried.

Note: If an imprint of both sides of the leaf is desired, place a sheet of developing paper next each side of the leaf.

Proof that dust arsenate of lead accompanies the indicator in proportions relative to the percentage of the original mixture has been obtained from the imprint paper in two ways: first, by quantitative analysis for arsenic; second, by qualitative analysis for lead by suspending the paper imprint in a stream of hydrogen sulphide and developing lead sulphide thereon. The results in both cases indicated the presence of the insecticide in direct proportion to the intensity of the indicator. In the case of insecticides other than arsenate of lead, this direct proportion has been assumed—not proven—and the method is offered on this basis.

In addition to both dust and spray applications of arsenate of lead we

have used the method in visualizing the distribution of calcium arsenate, nicotine and lime sulphur in both dust and spray applications. On the accompanying chart are shown paper imprints of the applications just mentioned.

This method was the result of our search for a means of determining the comparative efficiency of different types of dusting machinery when operating under the usual field conditions. It is unnecessary to go into any great detail regarding these tests. The results showed clearly a great difference in the efficiency of, for example, a hand duster and a high-powered mule duster, also a great difference in the evenness of application by each of these machines under still versus breeze applications. Of the many other interesting observations resulting from our field tests the following are the most significant: first, uniform coverage of tobacco leaves was not obtained even under ideal conditions, i. e., with no breeze, the best of dusters and an experienced operator—drooping tips and margins of leaves frequently showed very small dosages compared to the generally even distribution over the remainder of the plant: second, applied from above very little indeed of the insecticide adhered to the bottoms of the leaves except upon those near the ground which were covered on the rebound from the soil: third, dust was recovered farther from the treated row under still conditions of application than under breeze conditions notwithstanding the fact that in the latter case the sample leaves were taken directly to the leeward of the dusted rows,—at a distance of 45 feet almost no indication of the presence of the insecticide was obtained following a breeze application while a very definite indication was obtained at that distance from an application under still conditions.

We offer the method in the hope that its comparative simplicity, delicacy of indication and latitude of application may render it useful to other workers in obtaining desired data upon the problems to which it may be applicable.

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MR. C. C. HAMILTON: I would like to ask Mr. Morgan whether when they dissolved their phenolphthalein in the alcohol and then mixed it with the water or spray material, the phenolphthalein was attracted to the particles of lead arsenate, or whether it was shown by general distribution or some other method.

MR. A. C. MORGAN: I can't answer you from the chemical standpoint. We did make those tests and seemed to have a thorough distribution of the phenolphthalein through the spray.

MR. C. C. HAMILTON: I could understand how it would work with the dust, but didn't know how it worked with the liquid spray.

MR. A. C. MORGAN: It was more or less of a colloidal mixture, so Mr. Mewborne declared.

VICE-PRESIDENT R. W. HARNED: The next paper is by C. C. Hamilton and C. M. Smith.

## A COLORIMETRIC METHOD FOR SHOWING THE DISTRIBUTION AND QUANTITY OF LEAD ARSENATE UPON SPRAYED AND DUSTED SURFACES

By C. C. HAMILTON, *Associate Entomologist, University of Maryland* and C. M. SMITH, *Chemist, U. S. Bureau of Chemistry, Washington, D. C.*

(Paper not received in time for insertion here.)

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MR. PHILIP GARMAN: I would like to ask Dr. Hamilton what effect a mixture of sulphur or lime sulphur would have with lead arsenate.

MR. C. C. HAMILTON: The method worked with lime sulphur and lead arsenate used together and also with a combination.

MR. E. G. KELLY: Has it been tested out with Bordeaux mixture?

MR. C. C. HAMILTON: No, it hasn't been tested out with Bordeaux.

President Burgess resumed the Chair.

PRESIDENT A. F. BURGESS: The next paper is by E. A. Back and R. T. Cotton.

## A NEWLY RECOMMENDED FUMIGANT, ETHYL ACETATE IN COMBINATION WITH CARBON TETRACHLORIDE

By E. A. BACK and R. T. COTTON, *Stored Product Insect Investigations, Bureau of Entomology, U. S. Department of Agriculture*

ABSTRACT

A fumigant made by mixing 40 parts of ethyl acetate and 60 parts of carbon tetrachloride has been recommended for the fumigation of grain in grain cars when used at the rate of 40 to 50 pounds per thousand cubic feet of space (U. S. Department of Agriculture Bulletin 1313). Experiments reported upon herewith indicate that good results may follow its use in very tight containers in household fumigation and in well constructed covered grain bins on the farm. Fumigation of slip shuck corn during October in South Georgia proved a failure when conducted in well constructed wooden cribs in which carbon disulphid has been used successfully. It would seem that the ethyl acetate-carbon tetrachloride mixture requires a tighter container than carbon disulphid and possibly a higher minimum temperature. The new mixture must be made of pure or very nearly pure chemicals since the odoriferous constituents will taint grain and flour. The new fumigant is more expensive than carbon disulphid (costing f. o. b. Baltimore, from 12 to 15 cents per pound) has not

injured the viability of seeds tested and produces a gas that is non-explosive and non-inflammable at ordinary temperatures.

## Introduction

Cooperative work between the Bureaus of Chemistry and Entomology of the U. S. Department of Agriculture has developed recently a new fumigant for treating insect-infested wheat in railway cars. This fumigant is known as ethyl acetate-carbon tetrachloride mixture and is made of 40 parts of ethyl acetate mixed with 60 parts of carbon tetrachloride. The chemicals must be pure or nearly so else odoriferous constituents will be retained by the grain and render the flour and finished loaf of bread tainted. The gas formed by the volatilization of the liquid is heavier than air, is non-inflammable and non-explosive under ordinary conditions, is pleasant and simple to use, has no injurious effect on the baking qualities of wheat and does not affect the viability of seeds. The present cost of the mixture f. o. b. Baltimore, in 50 lb. tins is 15 cents per pound. The results of the cooperative work above referred to has been published as Bulletin 1313 of the U. S. Department of Agriculture.

Numerous tests have shown that with ordinary summer temperatures this fumigant when used to treat wheat in railway cars at the rate of 45–50 pounds per 1000 cubic feet of space is practically as effective as carbon disulphid.

Further experiments to determine the usefulness of this mixture for general fumigation work with household and stored product insects have been carried on by the writers and will be presented at this time.

## Use in Small Containers

In order to test the value of the new fumigant for household purposes experiments were carried on in containers such as are in common use in the average home. Specimens of a variety of insects that attack clothing and foodstuffs of all kinds were placed in these containers and fumigated for twenty-four hours with different amounts of the fumigant. For comparative purposes similar experiments were also conducted with carbon disulphid the effectiveness of which is well known to all entomologists.

In the first set of experiments the container used was a large ash can having a content of about 3½ cubic feet. The insects were placed in the bottom of the can and the fumigant poured into a shallow dish near the top. The temperature throughout the experiment varied between 60°F. and 80°F. The ethyl acetate-carbon tetrachloride mixture was used at the rate of 30 pounds, 40 pounds, 50 pounds and 60 pounds per 1000 cubic feet of space and carbon disulphid at the rate of 5 pounds and 10

pounds per 1000 cubic feet of space. The results of this experiment are given in Table I.

TABLE I.—COMPARATIVE TOXICITY OF ETHYL ACETATE-CARBON TETRACHLORIDE MIXTURE AND CARBON DISULPHID IN SMALL CONTAINERS

| Insect | Stage | Number | % Killed when amt. Ethyl Acetate-Carbon Tetrachloride used per 1000 cu. ft. was— | | | | % Killed when amt. of Carbon Disulphid used per 1000 cu. ft. was | |
|---|---|---|---|---|---|---|---|---|
| | | | 30 lbs. | 40 lbs. | 50 lbs. | 60 lbs. | 5 lbs. | 10 lbs. |
| Bruchus obtectus | adult | 50 | 100% | 100% | 100% | 100% | 100% | 100% |
| Cryptolestes pusillus | " | 50 | 100 | 100 | 100 | 100 | 100 | 100 |
| Necrobia rufipes | " | 25 | 100 | 100 | 100 | 100 | 100 | 100 |
| " " | larva | 25 | 20 | 0 | 40 | 0 | 100 | 100 |
| Silvanus gemellatus | adult | 50 | 100 | 100 | 100 | 100 | 100 | 100 |
| Sitophilus oryza | " | 50 | 80 | 10 | 50 | 20 | 90 | 100 |
| Tenebrio obscurus | larva | 25 | 80 | 0 | 0 | 0 | 0 | 100 |
| Tenebroides mauritanicus | " | 25 | 0 | 0 | 0 | 0 | 0 | 100 |
| Tribolium confusum | adult | 50 | 100 | 100 | 100 | 100 | 100 | 100 |
| " " | larva | 50 | 50 | 50 | 10 | 0 | 80 | 100 |
| Tribolium ferrugineum | adult | 50 | 100 | 100 | 100 | 90 | 95 | 100 |
| " " | larva | 50 | 50 | 100 | 0 | 0 | 80 | 100 |

The kill as noted in the above table was decidedly poor except when carbon disulphid was used at the rate of 10 pounds per 1000 cubic feet, a very large dose for a closed container. The poor results may be partially accounted for, however, by the fact that the bottom of the can was not gas tight and more or less leakage occurred.

In the second set of experiments the container used was a wooden chest similar in size and construction to the ordinary cedar chest, and having a content of approximately 4½ cubic feet. The chest was filled with clothing of various kinds and the insects scattered through it.

TABLE II.—COMPARATIVE TOXICITY OF ETHYL ACETATE-CARBON TETRACHLORIDE MIXTURE AND CARBON DISULPHID IN SMALL CONTAINERS

| Insect | Stage | Number of Specimens | % Killed when amt. Ethyl Acetate-Carbon Tetrachloride used per 1000 cu. ft. was— | | % Killed when amt. of Carbon Disulphid used per 1000 cu. ft. was— | |
|---|---|---|---|---|---|---|
| | | | 40 lbs. | 50 lbs. | 5 lbs. | 10 lbs. |
| Anthrenus fasciatus | adult | 25 | 100 | 100 | 100 | 100 |
| " " | larva | 25 | 100 | 80 | 0 | 100 |
| Attagenus piceus | " | 25 | 100 | 100 | 80 | 100 |
| Bruchus obtectus | adult | 50 | 100 | 100 | 100 | 100 |
| Cryptolestes pusillus | " | 50 | 100 | 100 | 100 | 100 |
| Ephestia kuehniella | " | 50 | 100 | 100 | 100 | 100 |
| " " | larva | 50 | 100 | 100 | 100 | 100 |
| Gnathocerus cornutus | adult | 50 | 100 | 100 | 100 | 100 |
| " " | larva | 50 | 100 | 100 | 100 | 100 |
| Gnathocerus maxillosus | adult | 50 | 100 | 100 | 100 | 100 |
| " " | larva | 50 | 100 | 100 | 100 | 100 |
| Necrobia rufipes | adult | 25 | 100 | 100 | 100 | 100 |
| " " | larva | 25 | 80 | 50 | 100 | 100 |
| Oryzaephilus surinamensis | adult | 50 | 100 | 100 | 100 | 100 |
| Plodia interpunctella | " | 50 | 100 | 100 | 100 | 100 |
| " " | larva | 50 | 100 | 100 | 100 | 100 |
| Silvanus gemellatus | adult | 50 | 100 | 100 | 100 | 100 |
| " " | larva | 50 | 100 | 100 | 100 | 100 |
| Sitophilus oryza | adult | 50 | 70 | 100 | 100 | 100 |
| Tenebrio obscurus | larva | 50 | 100 | 0 | 15 | 100 |
| Tenebroides mauritanicus | adult | 25 | 100 | 100 | 100 | 100 |
| " " | larva | 25 | 100 | 100 | 0 | 100 |
| Tineola biselliella | adult | 25 | 100 | 100 | 100 | 100 |
| " " | larva | 50 | 75 | 100 | 80 | 100 |
| Tribolium confusum | adult | 50 | 100 | 100 | 100 | 100 |
| Tribolium ferrugineum | adult | 50 | 100 | 100 | 100 | 100 |

Ethyl acetate-carbon tetrachloride mixture was used at the rate of 40 pounds and 50 pounds per 1000 cubic feet and carbon disulphid at the rate of 5 pounds and 10 pounds per 1000 cubic feet. The temperature and the length of exposure was the same as for the previous experiment. The results are given in Table II.

As may be seen from this table the kill was nearly perfect, only a small percentage of the more resistant species surviving the fumigation. The 40 pound and 50 pound doses of ethyl acetate-carbon tetrachloride mixture were about equally efficient with the 5 pound dose of carbon disulphid although not quite so efficient as the 10 pound dose of carbon disulphid which gave a perfect kill. It might be well to note at this time that the larvae of *Necrobia rufipes*, *Tenebrio obscurus*, *Tenebroides mauritanicus*, *Tineola biselliella*, *Anthrenus fasciatus* and *Attagenus piceus* are probably more difficult to kill than any other of our stored product pests.

The third container used was a tightly constructed clothes cabinet, six feet high, two feet wide and about a foot deep. The door was provided with a rubber gasket and when closed made the cabinet practically gas tight. The insects were placed in the empty cabinet and fumigated for twenty-four hours with the ethyl acetate-carbon tetrachloride mixture at the rate of 40 pounds and 50 pounds per 1000 cubic feet and with

TABLE III.—COMPARATIVE TOXICITY OF ETHYL ACETATE-CARBON TETRACHLORIDE MIXTURE AND CARBON DISULPHID IN SMALL CONTAINERS

| Insect | Stage | Number of Specimens | % Killed when amt. Ethyl Acetate-Carbon tetrachloride used per 1000 cu. ft. was— 40 lbs. | 50 lbs. | % Killed when amt. of carbon disulphid used per 1000 cu. ft. was— 5 lbs. |
|---|---|---|---|---|---|
| Anthrenus fasciatus | adult | 50 | 100 | 100 | 100 |
| " " | larva | 50 | 100 | 100 | 100 |
| Attagenus piceus | " | 25 | 100 | 100 | 100 |
| Bruchus obtectus | adult | 50 | 100 | 100 | 100 |
| Cryptolestes pusillus | " | 50 | 100 | 100 | 100 |
| Ephestia kuehniella | " | 50 | 100 | 100 | 100 |
| " | larva | 50 | 100 | 100 | 100 |
| Gnathocerus cornutus | adult | 50 | 100 | 100 | 100 |
| " " | larva | 50 | 100 | 100 | 100 |
| Gnathocerus maxillosus | adult | 50 | 100 | 100 | 100 |
| " " | larva | 50 | 100 | 100 | 100 |
| Necrobia rufipes | adult | 25 | 100 | 100 | 100 |
| " " | larva | 25 | 100 | 100 | 100 |
| Oryzaephilus surinamensis | adult | 50 | 100 | 100 | 100 |
| Plodia interpunctella | " | 50 | 100 | 100 | 100 |
| " " | larva | 50 | 100 | 100 | 100 |
| Silvanus gemellatus | adult | 50 | 100 | 100 | 100 |
| " " | larva | 50 | 100 | 100 | 100 |
| Sitophilus oryza | adult | 50 | 100 | 100 | 100 |
| Tenebrio obscurus | larva | 50 | 100 | 100 | 100 |
| Tenebroides mauritanicus | adult | 25 | 100 | 100 | 100 |
| " " | larva | 25 | 100 | 100 | 100 |
| Tineola biselliella | adult | 25 | 100 | 100 | 100 |
| " " | larva | 50 | 100 | 100 | 100 |
| Tribolium confusum | adult | 50 | 100 | 100 | 100 |
| Tribolium ferruginum | " | 50 | 100 | 100 | 100 |
| Trogoderma tarsale | larva | 25 | 100 | 100 | 100 |

carbon disulphid at the rate of 5 pounds per 1000 cubic feet. The temperature was the same as for the preceding experiments. The results are given in Table III.

As may be seen from this table the kill was perfect in all cases in which the clothes cabinet was used.

## Use in Corn Cribs

In order to test the efficiency of the new fumigant for farm use a number of experiments were made with different types of corn cribs. Six cribs were fumigated in all, one a galvanized iron crib, the rest wooden and rather well constructed. The capacity of the cribs varied from 1680 cubic feet to 4760 cubic feet. They were all filled with slip shucked corn which was rather heavily infested with the rice weevil, *Sitophilus oryza*, and the square necked grain beetle, *Silvanus gemellatus*. A light infestation of the pink corn worm, *Pyroderces rileyi* was also present. Each crib was fumigated with ethyl acetate-carbon tetrachloride mixture at the rate of 40 pounds per 1000 cubic feet and for comparative purposes some of them were later fumigated with carbon disulphid. The fumigations were all conducted near Thomasville, Georgia, where the prevailing temperature for the duration of the experiments averaged about 70°F. The length of each exposure was approximately 24 hours.

After the fumigations a number of ears of corn were removed from

Table IV.—Comparative Toxicity of Ethyl Acetate-Carbon Tetrachloride Mixture and Carbon Disulphid in Crib Fumigation of Slip Shucked Corn

| Type of Crib Used | Fumigant Used | No. of Ears Examined | No. of *Sitophilus oryza* found— | | No. of *Silvanus gemellatus* found— | | No. of *Pyroderces rileyi* found— | | % of all insects killed |
|---|---|---|---|---|---|---|---|---|---|
| | | | dead | alive | dead | alive | dead | alive | |
| Galvanized iron crib | Ethyl acetate-Carbon tetrachloride, 40 lbs. per 1000 cu. ft. | 20 | 978 | 228 | 1230 | 4 | 36 | 4 | 90 |
| Wooden crib 12′x14′x10′ | Ethyl acetate-Carbon tetrachloride, 40 lbs. per 1000 cu. ft. | 20 | 38 | 698 | 23 | 513 | 3 | 11 | 5 |
| Wooden crib 12′x14′x10′ | Carbon disulphid, 25 lbs. per 1000 cu. ft. | 20 | 954 | 15 | 765 | 5 | 123 | 12 | 98 |
| Wooden crib 14′x17′x20′ | Ethyl acetate-Carbon tetrachloride, 40 lbs. per 1000 cu. ft. | 20 | 89 | 1454 | 114 | 663 | 0 | 31 | 8 |
| Wooden crib 14′x17′x20′ | $CS_2$, 35 lbs. per 1000 cu. ft. | 20 | 1015 | 1 | 443 | 2 | 68 | 4 | 99 |
| Wooden crib 15′x10′x8′ | Ethyl acetate-Carbon tetrachloride, 40 lbs. per 1000 cu. ft. | 20 | 0 | 3250 | 50 | 1255 | 0 | 63 | 1 |
| Wooden crib 15′x10′x8′ | $CS_2$, 20 lbs. per 1000 cu. ft. | 20 | 2870 | 6 | 1338 | 12 | 64 | 2 | 99 |
| Wooden crib 18′x12′x8′ | Ethyl acetate-Carbon tetrachloride, 40 lbs. per 1000 cu. ft. | 20 | 5 | 918 | 27 | 300 | 8 | 9 | 3 |
| Wooden crib 20′x20′x10′ | Ethyl acetate-Carbon tetrachloride, 40 lbs. per 1000 cu. ft. | 20 | 216 | 189 | 662 | 29 | 26 | 4 | 80 |

different sections of the cribs, held for a few days and then examined. The results of these fumigations are given in Table IV.

The results as given in Table IV clearly show that unless the crib to be fumigated is extraordinarily tight it is impracticable to fumigate slip shucked corn with ethyl acetate-carbon tetrachloride mixture. All the cribs used have been fumigated successfully in the past with carbon disulphid which is proof in itself that they were well constructed. They belonged to progressive farmers who built them with a view to fumigation.

## Conclusion

It would appear that satisfactory results can be obtained with the ethyl acetate-carbon tetrachloride mixture as a household fumigant if it is used in a very tight container. It is more expensive than carbon disulphid but has the advantage of being non-explosive and non-inflammable at ordinary temperatures and in addition possesses a rather agreeable odor. It has given good results when used as a fumigant for threshed grain in box cars, and well constructed, covered bins but tests in farmers' cribs in South Georgia during October indicate that it is not so dependable under conditions satisfactory for the use of carbon disulphid.[1]

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Mr. R. N. Chapman: I should like to ask Mr. Cotton what he can tell us as to whether these two materials if put together are indifferent to each other, whether they complement each other or are antagonistic to each other in their action?

I suggested to Mr. Strand of the University of Minnesota that he try to see if he could find this out. Making a test in a closed container with a concentration of forty pounds to the thousand cubic feet, and taking the time at which one hundred per cent of Tribolium were killed as points on the curve, he got the following data:

With ethyl acetate alone, 25 minutes were required. With carbon tetrachloride alone 35 to 50 minutes were required; with a mixture of the two, 90 minutes.

This made it seem to us that they were acting indifferently, and that when they combined the two they were attempting to kill the insects twice; also, if we used the same amount of money required to buy the

[1]During late March, 1925, a covered tight bin 70 feet deep containing about 3500 bushels of wheat and an uncovered star-shaped bin containing 5500 bushels of wheat were successfully fumigated in Kansas City. Grain interests present were quite satisfied with the toxicity results but criticized the odor left in the grain.

mixture and bought nothing but carbon tetrachloride, we could buy 60 pounds of it to the thousand cubic feet, which is about five gallons.

I would like to ask Mr. Cotton if he knows anything about whether these are complementary, antagonistic, or indifferent.

MR. R. T. COTTON: We have found that carbon tetrachloride alone gives very indifferent results as to killing qualities. Sometimes we get fairly good kill, but in some cases we get no kill at all. Mr. R. C. Roark, who was the chemist in the co-operative experiments with these chemicals, is present I believe and I will ask him if he can tell us something about the antagonism between the two mixtures.

MR. R. C. ROARK: Of course, the purpose of adding carbon tetrachloride is to make a non-inflammable mixture.

MR. C. L. METCALF: I would like to ask if any one can answer the question as to whether a mixture of carbon disulphid and carbon tetrachloride can be employed, that will not be explosive.

MR. R. C. ROARK: The boiling points of ethyl acetate and carbon tetrachloride are almost identical. They lie within about half a degree centigrade of each other. Furthermore, their vapor pressures at low temperatures are almost the same, so that when you make a mixture of ethyl acetate and carbon tetrachloride, the two constituents do not tend to separate; but the boiling point of carbon disulphid is over twenty degrees lower than that of the carbon tetrachloride and at low temperatures its vapor pressure is very much greater than that of carbon tetrachloride, so that a mixture of carbon tetrachloride and carbon disulphid tends to separate. In order to get a non-inflammable mixture of carbon tetrachloride and carbon disulphid you have to use ninety-five parts of the carbon tetrachloride and five parts of the carbon disulphid, and to all intents and purposes you are using carbon tetrachloride straight.

MR. R. N. CHAPMAN: May I remark that the Underwriters Laboratory of Chicago have made a series of tests on various combinations of carbon tetrachloride and carbon disulphid and it is under their ruling that carbon disulphid is prohibited? They concluded that when the two were mixed the carbon disulphid exploded independently and the fact that its explosion was immediately extinguished by the presence of carbon tetrachloride mattered not because it might be followed immediately by an explosion of dust. Therefore, they ruled that no mixture of carbon tetrachloride and carbon disulphid should be used.

PRESIDENT A. F. BURGESS: The next is a paper by Messrs. Simmons and Ellington.

# THE CAUSES OF OUTBREAKS OF THE ANGOUMOIS GRAIN MOTH[1]

By PEREZ SIMMONS, *Associate Entomologist*, and GEORGE W. ELLINGTON, *Junior Entomologist, Stored Product Insect Investigations, Bureau of Entomology, Silver Spring, Md.*

ABSTRACT

A study of the environment of the Angoumois grain moth, *Sitotroga cerealella* Oliv., in a selected area (the vicinity of Philadelphia) during the past 28 years indicates that the principal factor influencing the occurrence of moth outbreaks there is the temperature from June to October. Time of harvest and winter temperatures also appear to be of importance.

In the literature of the Angoumois grain moth occasional suggestions may be found to account for years of unusual moth abundance. These explanations include: mild winter weather; hot, dry weather in summer; damp grain, and early harvest. There has been no attempt, however, to make a detailed examination of the factors involved, and the present paper is submitted as an effort to go farther into the question.

How may an outbreak of this insect be defined? There is always some loss from it in the Atlantic Coast wheat region, and no sharp boundary between the various degrees of damage would be expected. But as a matter of experience, certain years have stood out definitely from others as years of very serious infestation and are referred to as outbreak years.

A list of factors which may, conceivably, influence moth abundance either positively or negatively comprises: (1) temperature, (2) relative humidity, (3) amount and distribution of precipitation, (4) percentage of possible sunshine, (5) air movement, (6) time of harvest, (7) rate of progress in threshing, (8) moisture content of wheat, (9) carry-over or farm reserve of wheat and corn, (10) infestation of grain the previous season, (11) extent of the use of fumigants, and (12) parasitism. A few others, such as the activities of predators, heating of bulk wheat in winter, and commerce in infested grain, might be added, but it seems best to omit the most obscure and apparently least important considerations.

Measurements of the first 5 of the above influences have been recorded by the Weather Bureau, which has also preserved many observations on the time of harvest. Estimates of the farm reserve of wheat and corn are among the records of the Bureau of Agricultural Economics. Factors that are difficult to measure or for which data are not available are those numbered 7, 8, 10, 11, and 12.

[1] *Sitotroga cerealella* Oliv. The female may lay as many as 389 eggs. The larvae feed and pupate within stored grains, principally wheat and corn. But one larva usually attacks a wheat kernel. The minimum life cycle occupies about one month. Winter is passed as an immature insect within stored grains, from which the females fly to lay eggs on developing wheat heads and on harvested wheat.

## The Philadelphia District

For the purpose of studying the causes of outbreaks of the Angoumois grain moth it is desirable to examine past conditions in a locality

Fig. 16.—Map showing location of the Philadelphia district to which the accompanying discussion applies.

well represented by records of severe infestation. In this respect the most favorable area is the district around Philadelphia, shown in Figure 16. For convenience a circle with a 50-mile radius has been drawn around that city, enclosing part of New Jersey, southeastern Pennsylvania, and a small portion of Delaware and Maryland. This area produces much wheat, and may be said to be climatically the same throughout. It is located in the corn and winter wheat belt, shown in Figure 17. The agriculture consists typically of a rotation of corn, wheat, and hay.

There have been at least 7 outbreaks of the moth in this district during the past 28 years. Although there are earlier records of considerable localized damage to wheat there, the first acceptable record of an extensive outbreak is that of 1898 (*1*, *2*, *3*)[2]. The year 1899 was the occasion of but little injury by the moth, but the following year wheat growers experienced the most severe epidemic up to that time (*4*, *5*, *6*). In 1901 a large amount of damage was done in southeastern Pennsylvania (*8*) and in Delaware (*5*). Damage continued in New Jersey in 1901, but was somewhat less than in 1900 since acreage had been reduced and early threshing practiced in many cases because of the discouraging experiences with the insect the year before (*7*).

Losses from the moth appear to have been moderate from 1901 to 1908, when New Jersey was visited by a very severe outbreak (*11*). The infestation that year was widespread; wheat was seriously damaged in Maryland (*10*, *12*) and Delaware (*9*). From 1908 to 1921, no outbreaks are on record, but in 1921, 1922, and 1923, wheat growers and millers were again hard hit by the ravages of the insect. These three outbreaks were extensive, involving the wheat sections of New Jersey, Pennsylvania, Delaware, Maryland, and Virginia. The Philadelphia District suffered heavy losses from the insect during those years.[3] In 1924 the moth was present in comparatively small numbers.

The outbreaks listed all occurred within the district around Philadelphia, and while the probabilities are that local conditions protected certain parts of the area from extensive damage during outbreak years, it is assumed that outbreak conditions characterized the district as a whole during the years indicated. On the other hand, there are records of heavy localized infestations in the district during non-outbreak years,[4] but in those years the area was probably not subject to severe losses on the whole.

An investigation of the 12 factors listed above as possibly influencing moth increase has resulted in their rearrangement into two classes. One class includes factors which appear to exert a controlling influence; the other contains the more vague or seemingly less important components of the insect's environment. The controlling forces will be considered first. They are summarized in Table 1.

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[2]Reference is made by number (italic) to "Literature Cited."

[3]Shown by correspondence, by Stuart's recent publication (*15*), and by a 10-year, county-by-county summary of moth conditions in Pa. received from Mr. A. L. Strand, formerly Extension Entomologist on Angoumois grain moth for the Pa. State College.

[4]Strand's summary of moth conditions shows that infestation was heavy in Northhampton and Montgomery counties during 1919 and 1920.

Fig. 17.—Map showing the agricultural regions of the United States east of the Rocky Mountains, adapted from U. S. D. A. Yearbook, 1921, p. 416. Replies to inquiries sent to all states (except Vt., Mass. and Md.), and other sources of information, indicate that practically all important damage to wheat by the Angoumois grain moth takes place within the boundaries of the corn and winter wheat belt.

## Primary Factors Influencing Moth Abundance

In the eighth column of Table 1 is a description of each harvest since 1897, the year preceding the first outbreak. No complete list of the dates on which wheat harvest began in the Philadelphia District has been found, but it is possible to tell in a general way whether wheat began to ripen early, normally—about July first (*13*)—, or late, in any given year by scanning the climatological data for June. A hot, dry, sunny June is favorable for early ripening; a cool, wet, cloudy June delays ripening.

The descriptions obtained by inspection of weather records for June were checked, so far as the incomplete series of observations permitted, with weather-and-crop information published by the Weather Bureau for southeastern Pennsylvania. They were then compared with records on file at the Philadelphia office of the Weather Bureau,[5] with the result that descriptions arrived at by inspection of June weather data have been corrected by comparisons with phenological observations for each year except 1910 to 1913, both inclusive. Wheat harvests in near-by New Jersey are assumed to have been the same. Owing principally to uneven distribution of rainfall, there have probably been local exceptions to the descriptions given.

There appears to have been a range of about 4 weeks between the earliest and latest harvests in the Philadelphia District. According to Smith (*11*), the 1908 harvest in New Jersey was as much as 2 weeks earlier than usual, and the Weather Bureau reported the 1924 harvest in southeastern Pennsylvania as about two weeks later than normal. This extreme range approximates the minimum time required for the completion of the life cycle of the moth. As between a year with a very late harvest and one in which the wheat ripened extraordinarily early, there may, therefore, be a difference of nearly one in the number of generations which develop in the crop before cold weather, other things being equal. Such a difference would have an enormous effect on the ability of the insect to inflict damage.

During the 28 years from 1897 to 1924, wheat harvest began early eight times, normally 12 times, and late eight times. The seven bad moth years were marked by five early and two normal harvests. No outbreak took place in a year when wheat ripened late. Since but five of the eight early ripenings were followed by severe infestation, early harvests cannot be said to forecast outbreaks, but from the information at hand late harvests appear to assure freedom from great damage to the crop.

[5]The writers are indebted to Dr. George S. Bliss, meteorologist in charge of the Pennsylvania Section, for this assistance.

The temperature data in Table 1 are intended to serve as a gross measure of temperature conditions in the district during the past 28 years. They are based upon the monthly mean temperatures recorded at Philadelphia. The year has been divided into three parts; the winter period, from November to February, when unfavorably low temperatures occur; the spring period, from March to May, when neither very low nor very high temperatures are common; the summer-autumn period, from June to October, when warm weather and abundant new-crop wheat combine to furnish excellent conditions for moth increase.

The figures in the second and third columns of the table show the total accumulated excesses and deficiencies of temperature during the winters. They were obtained for each year by adding the four departures of the monthly means from the monthly normals. For example, the severe winter of 1917 to 1918 is represented by an accumulated temperature deficiency of 18.5°F; the departure in November was minus 2.1°; in December, minus 8.0°; in January, minus 8.6°; in February, plus 0.2°.

The winter temperature figures show that bad moth years have usually been preceded by warm winters, but that even extreme winter mildness does not forecast an outbreak for the following summer. Of the 17 winters which were warmer than normal, but six preceded outbreaks, and the three warmest winters were not followed by outbreaks. On the other hand, no outbreaks followed the five coldest winters, which suggests that very cold winters have a strong influence in preventing the survival of enough moths to make possible heavy damage to the crop. Whether or not an unusually hot summer is able to overcome the repressive effect of a severe preceding winter remains to be demonstrated. The year 1920 does not afford a good example of such a condition because nearly all the excess temperature that accumulated during the summer-autumn of that year was recorded in October, at the end of the season of rapid moth increase. The absence of an outbreak in 1899 is quite significant, since a hot summer, accompanied by an early harvest, followed a winter that was colder than normal; and the lowest temperature of the 28 years (–6°F.) occurred in February of that year.

Spring temperature abnormalities do not show any decisive effect upon moth conditions. The spring is a time of rather slow development, principally in depleted and increasingly scattered holdings of bulk wheat and in diminished, though large and well distributed, stocks of ear corn. Two of the seven outbreaks followed cool springs, and of the 21 warm or normal springs but five were followed by outbreaks. Three of the four warmest springs were not precedent to unusual abundance

of the insect. Although there can be no doubt that a warm spring provides good conditions for the development of the moths, the effect of such a spring appears to be subordinate to other influences.

The summer-autumn accumulated temperature departures bear a close relation to outbreaks. As the table shows, bad moth years have been marked by abnormally hot summer-autumn periods, without exception. No cool summer-autumn has been the occasion of an outbreak. The record-breaking heat of 1900 is correlated with an outbreak of maximum intensity.

Although there have been hot years without heavy losses from the insect, each of the five hottest summer-autumns during the past 28 years has been the occasion of an outbreak. In the seven outbreak years the Junes were all hotter than normal, and in five of them(1898, 1900, 1901, 1908, 1921) both June and July were abnormally hot. Conversely, from 1897 to 1924 there were six years (1898, 1900, 1901, 1908, 1913, 1921) in which both June and July were hotter than normal by more than 0.5°F., and five of them are known to have been outbreak years.

From the evidence at hand it seems fair to propose the hypothesis that in the absence of considerable above-normal temperature accumulations from June to October, all other influences favorable to the development of the Angoumois grain moth are incapable of causing an outbreak in the Philadelphia District. On the other hand, a large accumulated temperature excess during the summer and autumn is very likely to be accompanied by an outbreak, especially if the preceding winter was mild and June and July unusually hot. Early harvests, which are related to hot weather in June, enable the moth to get an early start in the new crop of wheat; late harvests appear to forecast seasons of moderate or light losses from the insect.

## Secondary Factors Influencing Moth Abundance

The relative humidity of the air has been found by the writers to have a bearing on the fecundity of moths in trials wherein the effect of a nearly saturated atmosphere was compared with that of the dry air of an office, but it seems unlikely that humidities at Philadelphia become so low as to have an adverse effect on reproduction. The average humidity at Philadelphia during the summer-autumn period, based on monthly normals computed from 8:00 A.M. and 8:00 P.M. readings for 23 years, is 71 per cent. A summary of the monthly departures from normal humidities for the summer-autumn periods from 1897 to 1923, shows no correlation between such departures and moth outbreaks.

In the outbreak year 1921, humidity departures were remarkably high, while in 1923 they were unusually low.

Laboratory experiments have shown that a supply of drinking water for the female moths is essential to maximum fecundity. Although there are probably times when moths in the field are unable to get drinking water either in the form of rain water or dew, it is probable that troughs and streams near the farm buildings where the insects originate largely provide for their needs under such conditions. A summary of summer-autumn precipitation data, 1897 to 1923, shows that while outbreak years have usually been dry in June and July, unusually dry summers have sometimes been too cool to permit great increase in the moth population.

During the greater part of the year the insects are generally protected from rain and snow. The exception is the period of about a month (three or four weeks before harvest and a week or 10 days after) when the moths are laying eggs on the wheat in the field. Adults and newly hatched larvae are then more or less exposed to the washing of occasional heavy rainstorms, but on the whole mortality from this cause probably has little effect on outbreaks.

The moisture content of wheat is affected both by atmospheric humidity and by rainfall. While not much is known about the metabolic response of grain insects to different percentages of moisture in their food, moist grain is understood to be favorable to development and low percentages of water (e. g., below 10 per cent) are considered unfavorable. The Angoumois grain moth begins development in the green, milky kernels of growing wheat; as the grain matures, and after it is cut and shocked, it becomes progressively drier. Since certain years of severe moth damage have been dry during the summer and fall, it seems fair to assume that new-crop wheat in this locality seldom becomes so dry as to retard moth increase. Safe storage requires a moisture content of less than 15 per cent, and while this amount is not infrequently exceeded in eastern soft red winter wheat (*14*), the average of the crop in the Philadelphia District is probably always less, which suggests that the average is never high enough greatly to accelerate moth development.

As is the case with precipitation, the amount of sunshine indirectly affects outbreaks because of its influence on the time of wheat ripening. Aside from this relation, there appears to be no reason to suppose that sunshine influences outbreaks.

The activities of the female moths in the field may be hindered at times by high winds, but air movement is probably a very small factor in the environment of this species so far as outbreaks are concerned.

The estimated percentages of carry-over of wheat and corn in Pennsylvania for the past 28 years are given in Table 2. The wheat crop of that State has ranged, in round numbers, from 17 to 30 million bushels, with an average of 25 million bushels; the corn crop has ranged from 33 to 76 million bushels, with an average of about 56 million bushels. The information in Table 2, therefore, shows the farm-stored grain situation in Pennsylvania in a general way only. These figures are assumed to be fairly representative of past conditions in the Philadelphia District. No fluctuations have occurred in the farm reserve, when expressed either in terms of bushels or percentages, which seem to be significant with respect to moth outbreaks. The data for corn are included for the reason that infested ear corn stored in cribs is perhaps the most important of the sources which give rise to the moths that begin the infestation of the new wheat crop.

The rate of progress in threshing the wheat crop has been subject to some variation since 1897, due to the efforts of public service agencies concerned with the reduction of losses by the moth. In 1901, following the memorable outbreak of 1900, threshing from the field was practiced to a considerable extent in New Jersey, as already noted. During the heavy infestations of 1921, 1922, and 1923, the importance of early threshing was emphasized anew. These efforts have doubtless ameliorated the moth situation, but were obviously insufficient to prevent outbreaks.

The degree of infestation of the preceding crop of wheat would be expected to influence the number of moths present when infestation of a new crop begins, especially if the intervening winter be mild. As shown in Table 1, however, such a situation does not predetermine an outbreak; an instance is the absence of heavy losses in 1909. The natural tendency for a high degree of infestation to impress its influence on the subsequent crop seems to be overwhelmed by other positive and negative factors.

The amount of control afforded by the use of fumigants has not been of appreciable help in preventing outbreaks. Carbon disulphid is a very useful fumigant, but its application here and there to check infestations that are well advanced probably affects the whole moth situation very little, especially since infested stores of corn are not often fumigated. Other measures of sanitation, such as baling straw and cleaning up scattered grain, have probably had no greater effect. As Stuart (*15*, p.7) states, "No organized effort has been made by the farmers of any community to control the pest."

Immature stages of the moth are often parasitized, by both hymenopterous and acarid enemies. Fernald (*2*) found parasites plentiful, but not abundant enough to prevent large losses. Smith (*3, 7*) reported that parasites were numerous in the 1898 and 1901 crops of wheat, but

TABLE 1.—IMPORTANT FACTORS AFFECTING THE ABUNDANCE OF THE ANGOUMOIS GRAIN MOTH—PHILADELPHIA DISTRICT

| Year | Accumulated monthly departures of monthly mean temperatures from monthly normals at Philadelphia | | | | | | Beginning of wheat harvest | Recorded moth outbreaks |
|---|---|---|---|---|---|---|---|---|
| | Winter (11, 12, 1, 2) | | Spring (3, 4, 5) | | Summer-autumn (6, 7, 8, 9, 10) | | | |
| | plus | minus | plus | minus | plus | minus | | |
| 1897 | 4.2 | | 2.8 | | | 1.7 | late | |
| 1898 | 7.5 | | 3.2 | | 9.4 | | early | severe |
| 1899 | | 6.5 | 1.8 | | 4.0 | | early | |
| 1900 | 3.5 | | | 1.5 | 17.4 | | early | very severe |
| 1901 | | 1.3 | | 3.1 | 7.3 | | normal | severe |
| 1902 | | 9.5 | 5.9 | | | 3.9 | normal | |
| 1903 | 6.2 | | 12.7 | | | 9.4 | late | |
| 1904 | | 19.8 | | 1.6 | | 7.1 | normal | |
| 1905 | | 18.4 | 3.5 | | | 0.2 | normal | |
| 1906 | 9.9 | | 0.7 | | 4.4 | | normal | |
| 1907 | | 3.8 | | 6.4 | | 7.2 | late | |
| 1908 | 4.2 | | 7.7 | | 5.6 | | early | very severe |
| 1909 | 12.7 | | 2.3 | | | 4.7 | early | |
| 1910 | 4.0 | | 11.9 | | 3.2 | | late | |
| 1911 | | 2.2 | 2.4 | | 2.7 | | normal | |
| 1912 | | 6.2 | 0.9 | | 0.6 | | late | |
| 1913 | 17.9 | | 10.2 | | 4.1 | | normal | |
| 1914 | 6.1 | | 1.1 | | 2.6 | | normal | |
| 1915 | 7.4 | | 1.4 | | 1.5 | | late | |
| 1916 | 4.4 | | | 4.0 | 0.2 | | normal | |
| 1917 | 1.6 | | | 4.0 | | 4.5 | late | |
| 1918 | | 18.8 | 8.3 | | 0.3 | | normal | |
| 1919 | 16.3 | | 6.3 | | 4.5 | | early | |
| 1920 | | 10.0 | 0.1 | | 5.1 | | normal | |
| 1921 | 11.9 | | 17.9 | | 7.2 | | early | severe |
| 1922 | 2.8 | | 8.5 | | 4.4 | | normal | very severe |
| 1923 | 1.1 | | 0.9 | | 3.6 | | early | severe |
| 1924 | 10.6 | | | 3.5 | | 4.5 | late | |

Temperature items computed from "Annual Meteorological Summary with Comparative Data: Philadelphia, Pa., 1923," compiled under the direction of George S. Bliss, Meteorologist; and from "Climatological Data," Pa. Section, for each month in 1924. The monthly normals from which these departures are figured are the monthly means of Philadelphia temperatures from 1872 to 1923. These differ very slightly from the official monthly normals adopted for Philadelphia by the Weather Bureau at intervals of several years.

he believed that the greater part of the mortality caused by them took place after the moths had done a great deal of damage, and that parasites were possibly mainly beneficial in lessening the numbers of their hosts present during the succeeding year. The facts in the case are obscure, and both on this account and because the probability that temperature controls outbreaks appears so strong, parasites are listed among the secondary factors. There seem to be no records of the moth having been attacked by disease.

The writers realize the shortcomings of the present attempt to derive the causes of the occurrence and non-occurrence of outbreaks of the Angoumois grain moth. The evidence is fragmentary and not well adapted to treatment by mathematical methods. If detailed information were at hand to show the amount of damage done each year by the insect, it would be desirable to weight the monthly temperature departures with reference to their effect on moth increase, both with regard for their position in time and according to the magnitude of the normals from which they are computed; and a more detailed study of minimum winter temperatures would be appropriate. It is hoped, however, that the foregoing discussion may contribute something toward a better understanding of the influences which determine the abundance of the Angoumois grain moth.

TABLE 2.—FARM RESERVES OF WHEAT AND CORN IN PENNSYLVANIA

| Year | Wheat | | Corn | |
|---|---|---|---|---|
| | March 1 | July 1 | March 1 | Nov. 1 |
| | % | % | % | % |
| 1897 | 30 | 7.5 | 45 | 7.0 |
| 1898 | 34 | 4.3 | 39 | 5.2 |
| 1899 | 38 | 12.7 | 41 | 4.9 |
| 1900 | 35 | 14.1 | 39 | 5.0 |
| 1901 | 30 | 7.4 | 32 | 2.0 |
| 1902 | 36 | 10.7 | 38 | 4.0 |
| 1903 | 38 | 8.1 | 41 | 4.7 |
| 1904 | 28 | 6.8 | 32 | 3.1 |
| 1905 | 34 | 7.1 | 33 | 4.0 |
| 1906 | 36 | 7.4 | 37 | 3.5 |
| 1907 | 40 | 9.5 | 45 | 4.7 |
| 1908 | 38 | 7.2 | 39 | 3.4 |
| 1909 | 34 | 3.0 | 40 | 1.9 |
| 1910 | 36 | 6.0 | 29 | 3.4 |
| 1911 | 40 | 7.4 | 38 | 4.3 |
| 1912 | 28 | 6.2 | 34 | 4.0 |
| 1913 | 27 | 6.4 | 39 | 4.0 |
| 1914 | 30 | 7.0 | 38 | 3.0 |
| 1915 | 23 | 5.0 | 35 | 3.0 |
| 1916 | 35 | 9.0 | 37 | 3.0 |
| 1917 | 18 | 4.5 | 30 | 2.0 |
| 1918 | 26 | 4.0 | 37 | 3.0 |
| 1919 | 21 | 4.0 | 31 | 2.3 |
| 1920 | 23 | 5.5 | 40 | 4.7 |
| 1921 | 35 | 9.0 | 43 | 6.0 |
| 1922 | 25 | 7.0 | 42 | 5.0 |
| 1923 | 25 | 6.0 | 43 | 4.0 |
| 1924 | 29 | 7.0 | 40 | 4.0 |
| Av. | 31 | 7.1 | 38 | 3.9 |

Data secured through courtesy of Bureau of Agricultural Economics, U. S. Dept. of Agriculture. Percentages given refer to previous year's production.

LITERATURE CITED

1. JOHNSON, W. G., 1898. Notes from Md. on Principal Inj. Ins. of the Year. *In* Proc. 10th Ann. Meeting of the Assoc. of Ec. Entgsts. U. S. D. A. Div. Ent. Bul. 17 n. s.: 94.
2. FERNALD, H. T., 1899. Some Ins. Inj. to Wheat. Pa. Dept. Agri. Bul. 46: 20–23.
3. SMITH, J. B., 1899. Rept. Ent. Dept. N. J. Sta. for 1898: 380, 381.
4. HOWARD, L. O., 1901. The Angoumois Grain Moth in Pa. *In* Some Misc. Results of the Work of the Div. of Ent. U. S. D. A. Div. Ent. Bul. 30 n. s.: 86, 87.
5. SANDERSON, E. D., 1901. The Angoumois Grain Moth. Del. Coll. Exp. Sta. Press Bul. 10: 3 pp.
6. SMITH, J. B., 1901. Rept. Ent. Dept. N. J. Sta. for 1900: 491–494.
7. SMITH, J. B., 1902. Rept. Ent. Dept. N. J. Sta. for 1901: 488.
8. HOWARD, L. O., 1904. The Angoumois Grain Moth in 1901. *In* Some Misc. Results of the Work of the Div. of Ent. U. S. D. A. Bur. Ent. Bul. 38 n. s.: 93, 94.
9. HOUGHTON, C. O., 1909. Report on Ins. *In* Trans. 22nd Ann. Session of the Peninsula Hort. Soc. (Del.): 38–43.
10. PEAIRS, L. M., 1909. Rept. of Comm. on Ent. *In* Rept. Md. State Hort. Soc. for 1908: 61–63.
11. SMITH, J. B., 1909. Rept. Ent. Dept. N. J. Sta. for 1908: 335–337.
12. SYMONS, T. B., 1909. The Angoumois Grain Moth. Md. Sta. Bul. 137: 1.
13. BAKER, O. E., BROOKS, C. F., COVERT, J. R., and HAINSWORTH, R. G., 1922. Seedtime and Harvest. U. S. D. A. Dept. Circ. 183: 16.
14. BOERNER, E. G. and PHILLIPS, C. L., 1923. Moisture in Wheat. Mimeographed abstracts and references compiled in the office of grain investigations. Bur. of Agri. Economics, U. S. D. A.: 8, 9.
15. STUART, G. A., 1924. Problems in Marketing Pa. Wheat. Pa. Dept. Agri. Gen. Bul. 393.

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The meeting adjourned at 4.45 P. M.

*Saturday morning Session, January 3, 1925*

The meeting convened at 9:40 A. M., President A. F. Burgess presiding.

PRESIDENT A. F. BURGESS: The meeting will please come to order. The first paper on the program this morning is by R. W. Harned and H. W. Allen.

## CONTROLLING BEDBUGS IN STEAM-HEATED ROOMS

By R. W. HARNED, *Entomologist* and H. W. ALLEN, *Associate Entomologist, Mississippi Agricultural Experiment Station, A. & M. College, Mississippi*

ABSTRACT

During the summer of 1924 experiments were conducted in the dormitories of the Agricultural and Mechanical College of Mississippi for the control of bedbugs, *Cimex lectularius* Linn., by heat. Superheating of the infested rooms was secured

by closing the rooms and turning on the steam heat during hot summer weather. At temperatues of 120 degrees Fahrenheit and above, absolute control was secured by treatment of several hours duration. A very high percentage mortality was secured by exposures to temperatures averaging 110 degrees Fahrenheit when maintained for two days or more. The results obtained by the treatment of 350 dormitory rooms have proved so much better in respect to the saving of labor, safety and effectiveness than the method of fumigation with hydrocyanic acid gas that the latter method has been abandoned in favor of superheating for control of this pest.

During the summer of 1924, two experiments on the effectiveness of superheating rooms for the control of bedbugs, *Cimex lectularius* Linn., were made in the dormitories of the Mississippi Agricultural and Mechanical College which proved so highly satisfactory that this method will replace fumigation with hydrocyanic acid gas in future treatments at this place.

The dormitory is heated by steam from a central heating plant. Treatment in both experiments consisted in the extremely simple procedure of closing the doors, transoms and windows of the infested rooms and turning on the steam in all the radiators. Steam was maintained until inspection indicated that killing temperatures of sufficient duration had been secured in all the rooms treated. It was found possible to make a rapid inspection at any time during the experiment even in rooms having temperatures as high as 128 degrees Fahrenheit without extreme discomfort. The heat was then shut off, and the rooms allowed to cool slowly, thus securing the effect of several additional hours of killing temperatures before reaching normal temperature once more.

The first experiment was started on June 16 in 210 rooms on all four floors of the north, east and west wings of the dormitory. In this experiment, only two rooms were selected for temperature readings, one being on the inside and the other on the outside of the west wing on the third floor. The rooms were selected to represent an average condition of the whole number treated. Steam was turned on at 11 A. M. At this time, the temperature in the two selected rooms was 89 and 90 degrees Fahrenheit respectively. The temperature mounted rapidly, and by noon the following day had reached 122 degrees in one room and 128 degrees in the other. The heat was turned off after treatment of slightly more than two days. After cooling to normal the rooms were inspected, and but three living bugs were found. During the summer session, many of the treated rooms were occupied. On September 3d, several weeks after the rooms had been vacated, all the rooms in this experiment were again carefully inspected. Only three of the 210 rooms were found infested, and but one bug was discovered in each one of these.

For the second experiment, 140 rooms of the south and west wings were treated. Before the heat was turned on, a brief inspection was made of the rooms. Many were found to be heavily infested with living bugs. Sixteen rooms were selected in the south wing which was found to be most heavily infested. Four of the rooms chosen were located on each floor, two facing north upon the court and receiving no sunlight, the other two facing south and receiving sunlight during the middle of the day. Thermometers and boxes of living bedbugs were placed in each one of the selected rooms. Four boxes were placed in each room, the location of the boxes being approximately the same for every room. One was placed on a mattress on one of the beds, another was placed inside of a mattress folded back upon itself, or between two mattresses when two were found together, another on the floor at the center of the room, and a fourth on the floor by the outside wall. The containers used were clean, one-ounce tin salve boxes, and into these were placed living bedbugs, in the nymph and adult stages, collected within a few hours before the experiment was started. Several living specimens were placed in each box. The thermometers were placed upon the beds, in a position not far from the center of the room. Temperature readings were made at 8 A. M., 1 P. M. and 5 P. M. each day during the experiment.

Heat was turned on in all the rooms at 5:30 P. M. on August 26th. It was discovered that killing temperatures were much more readily secured in the west wing than in the south. The rooms of the west wing were examined after 63 hours of heating, temperatures being taken in several rooms of the two lower floors. When it was discovered that in all the temperature was above 120 degrees F., the heat was turned off in this wing to allow greater concentration of steam in the south wing. It was found impossible to secure in all of the rooms of the south wing, the maximum temperature of 120 degrees desired, even after receiving the benefit of a more concentrated flow of steam at the latter end of the test, but brief inspection during the experiment indicated that extensive killing had been secured by a long exposure to lower temperatures. The steam was turned off in this wing at 9 A. M. on August 30th after a total treatment of 87½ hours.

The temperatures were found to vary considerably in the different rooms. Rooms facing south received the additional heat of several hours of sunlight and in most cases attained higher temperatures than the rooms facing north and receiving no sunlight. Several rooms were discovered in which the temperatures were far below the average as a result of defective heating units. (Fig. 18). The daily fluctuation of

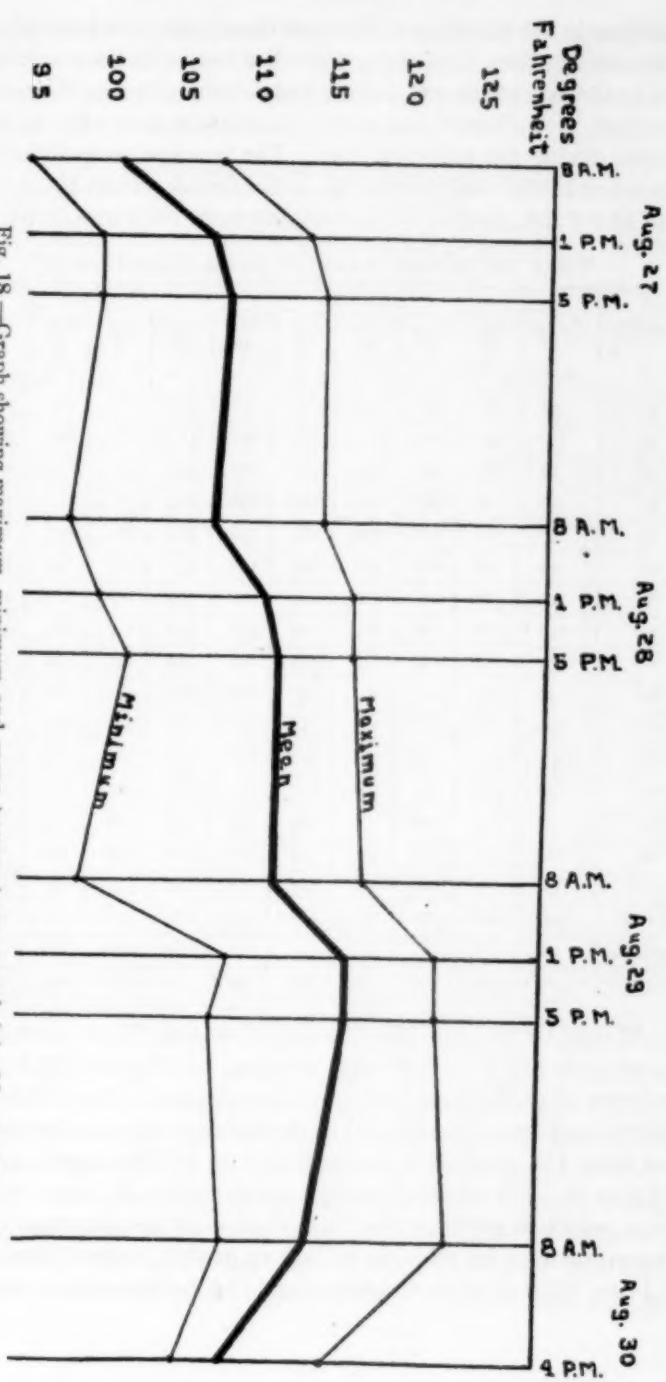


Fig. 18.—Graph showing maximum, minimum and mean temperatures recorded in 16 rooms during experiment to control bedbugs by heat in 140 rooms.

temperature in the experiment followed closely the usual outside fluctuation, for the first two days rising from the lowest in the morning to the highest in the late afternoon, falling away slightly during the night. The temperature rose slightly during the third night and very rapidly to a maximum during the following day. The average temperature for the sixteen rooms under observation rose on the first day from 101.6 at 8 A. M. to 108.7 at 5 P. M., and on the second day from 107.7 at 8 A. M. to 112.1

TABLE I.—SHOWING RANGE OF ROOM TEMPERATURES

| Room No. | Temperatures | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Aug. 27 8 a. m. | Aug. 27 1 p. m. | Aug. 27 5 p. m. | Aug. 28 8 a. m. | Aug. 28 1 p. m. | Aug. 28 5 p. m. | Aug. 29 8 a. m. | Aug. 29 1 p. m. | Aug. 29 5 p. m. | Aug. 30 8 a. m. | Aug. 30 4 p. m. |
| 1 | 97 | 102 | 106 | 108 | 114 | 115 | 114 | 119 | 118 | 111 | 108 |
| 2 | 102 | 109 | 109 | 111 | 117 | 117 | 117 | 122 | 119 | 115 | 110 |
| 3 | 95 | 100 | 100 | 104 | 108 | 108 | 109 | 111 | 110 | 111 | 106 |
| 4 | 95 | 100 | 100 | 106 | 108 | 109 | 110 | 114 | 114 | 114 | 109 |
| 5 | 97 | 105 | 107 | 108 | 109 | 110 | 113 | 116 | 117 | 118 | 110 |
| 6 | 99 | 104 | 106 | 106 | 108 | 108 | 110 | 114 | 114 | 117 | 111 |
| 7 | 100 | 105 | 107 | 106 | 109 | 109 | 109 | 115 | 114 | 111 | 108 |
| 8 | 102 | 108 | 109 | 109 | 112 | 113 | 115 | 117 | 117 | 116 | 108 |
| 9 | 107 | 112 | 113 | 115 | 115 | 116 | 117 | 120 | 122 | 124 | 116 |
| 10 | 99 | 106 | 108 | 107 | 108 | 109 | 110 | 115 | 117 | 118 | 109 |
| 11 | 109 | 111 | 115 | 108 | 115 | 116 | 119 | 123 | 123 | 119 | 113 |
| 12 | 108 | 111 | 114 | 114 | 117 | 117 | 118 | 122 | 121 | 118 | 111 |
| 13 | 108 | 113 | 115 | 108 | 110 | 111 | 110 | 116 | 117 | 113 | 108 |
| 14 | 97 | 108 | 109 | 98 | 100 | 102 | 99 | 109 | 108 | 111 | 107 |
| 15 | 104 | 114 | 112 | 108 | 115 | 117 | 112 | 119 | 120 | 109 | 106 |
| 16 | 106 | 112 | 109 | 109 | 116 | 117 | 114 | 120 | 121 | 110 | 107 |
| Average | 101.6 | 107.5 | 108.7 | 107.7 | 111.3 | 112.1 | 112.2 | 117.0 | 117.0 | 114.7 | 109.2 |
| Maximum | 108 | 114 | 115 | 115 | 117 | 117 | 118 | 123 | 123 | 124 | 116 |
| Minimum | 95 | 100 | 100 | 98 | 100 | 102 | 99 | 109 | 108 | 109 | 106 |

at 5 P. M. and on the third day from 112.2. at 8 A. M. to 117.0 at 5 P.M., falling away to 114.7 the following morning, and then to 109.2 at 4 P.M., seven hours after the heat had been discontinued. (See Table 1). The maximum temperatures attained in the sixteen rooms under observation ranged from 111 degrees in rooms 3 and 14 to 124 degrees in room 9. (See Table 2). The highest average temperature for three consecutive readings, which is perhaps the most significant temperature record for this experiment in its relation to bug mortality, ranged from 109.3 in room 14 to 122.0 in room 9, averaging 115.8 for the sixteen rooms.

The results of the treatment were determined by an examination of the boxes for mortality, and by a thorough room to room inspection of the whole section treated after it had cooled sufficiently to make work feasible. In the boxes which were removed at 4 P. M. on August 30th

TABLE II.—TEMPERATURE AND MORTALITY RECORD

| Temperatures | | | | Mortality | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | In box on mattress | | In box Within folded mattress | | In box On floor at center of room | | In box On floor by outside wall | | Totals | | |
| Room No. | Maximum Attained | Av. 3 Highest Consecutive Readings | Mean of All Readings | dead | alive | dead | alive | dead | alive | dead | alive | dead | alive | Per cent mortality |
| 1 | 119 | 117.0 | 110 | 6 | 0 | 5 | 0 | 5 | 0 | 5 | 0 | 21 | 0 | 100 |
| 2 | 122 | 119.3 | 113 | 5 | 0 | 6 | 0 | 5 | 0 | 5 | 0 | 21 | 0 | 100 |
| 3 | 111 | 110.7 | 106 | 5 | 0 | 2 | 3 | 6 | 0 | 5 | 0 | 18 | 3 | 85.7 |
| 4 | 114 | 114.0 | 107 | 4 | 0 | 6 | 0 | 4 | 0 | 6 | 0 | 20 | 0 | 100 |
| 5 | 118 | 117.0 | 110 | 5 | 0 | 6 | 0 | 5 | 0 | 5 | 0 | 21 | 0 | 100 |
| 6 | 117 | 115.0 | 109 | 12 | 0 | 5 | 0 | 5 | 0 | 5 | 0 | 27 | 0 | 100 |
| 7 | 116 | 113.3 | 108 | 5 | 0 | 5 | 0 | 8 | 0 | 5 | 0 | 23 | 0 | 100 |
| 8 | 117 | 116.7 | 111 | 5 | 0 | 6 | 0 | 10 | 0 | 5 | 0 | 26 | 0 | 100 |
| 9 | 124 | 122.0 | 116 | 5 | 0 | 7 | 0 | 5 | 0 | 5 | 0 | 22 | 0 | 100 |
| 10 | 118 | 116.7 | 110 | 7 | 0 | 6 | 0 | 5 | 0 | 4 | 0 | 22 | 0 | 100 |
| 11 | 123 | 121.7 | 116 | 5 | 0 | 7 | 0 | 5 | 0 | 5 | 0 | 22 | 0 | 100 |
| 12 | 122 | 120.3 | 116 | 5 | 0 | 5 | 0 | 5 | 0 | 5 | 0 | 20 | 0 | 100 |
| 13 | 117 | 115.3 | 112 | 7 | 0 | 5 | 0 | 6 | 0 | 5 | 0 | 23 | 0 | 100 |
| 14 | 111 | 109.3 | 104 | 6 | 0 | 5 | 0 | 4 | 0 | 6 | 0 | 21 | 0 | 100 |
| 15 | 120 | 117.0 | 112 | 9 | 0 | 6 | 0 | 6 | 0 | 5 | 0 | 26 | 0 | 100 |
| 16 | 121 | 118.3 | 113 | 6 | 0 | 6 | 0 | 5 | 0 | 5 | 0 | 22 | 0 | 100 |
| Totals and Averages | | 115.8 | 110.8 | 97 | 0 | 88 | 3 | 89 | 0 | 81 | 0 | 355 | 3 | |
| Per cent Mortality | | | | 100 | | 96.7 | | 100 | | 100 | | 99.2 | | |

and examined immediately there were 355 dead specimens and 3 living with a percentage mortality of 99.2. The only three living specimens found were from a box placed between two mattresses in room 3 in which the temperature never rose satisfactorily, the average sustained temperature for three consecutive readings in this room being 5.1 degrees lower than the average for the whole experiment, and the maximum temperature attained being but 111 degrees. In this same room as well as in all the others, mortality in the boxes placed on the mattresses, on the floor at the center of the room, and on the floor at the outside wall, was 100 per cent. Of the 355 dead specimens, 210 were nymphs and 145 adults, while of the three surviving, 2 were nymphs and one adult.

Fig. 19.—Graphical summary showing relation of room temperatures to mortality in 16 rooms during experiment to control bedbugs in 140 rooms.

Nymphs and adults were destroyed apparently with about equal effectiveness. Comparison of temperatures with mortality indicates that high mortality was secured at remarkably low temperature when this temperature was long sustained. For instance, in room 14, in which the maximum temperature attained was but 111 degrees and the average for the highest sustained temperature for three consecutive readings was 109.3, the control was 100 per cent. In several rooms in which the temperatures were scarcely higher, the results were the same. (Fig. I9)

The results from the inspection of the rooms after treatment checked very closely with those obtained from bugs exposed in boxes. Hundreds of dead, dried-up specimens were found. Living specimens were encountered in but two of the 140 rooms treated, and in one of these, the only living specimen was found paralyzed and helpless. In the other, room 3 of the sixteen room test, which also gave only a partial mortality in the box test, several living bedbgus were found beneath one of the mattresses. At this inspection, a list was made of all rooms in which eggs could be found. Such rooms were again inspected eleven days after the termination of the treatment, allowance having been made for the maximum time of hatching during summer heat.[1] No living nymphs were encountered except in room 3, in which a few were found. Since eggs were quite abundant in many of the rooms, this appears to indicate that eggs as well as nymphs and adults were destroyed by the heat.

Although the heat was maintained for three days to secure the penetration of high temperatures into the bedding of every room, a high mortality was secured in most rooms much earlier in the experiment. For the purpose of securing some information on the progress of mortality in this experiment, several additional boxes containing living material were placed near the center in several rooms.

In one of these rooms the temperature had attained 104° at 8 A. M. of the first day at which time, most of the bugs were still alive. At 1 P. M., the temperature had risen to 114, and all of the bugs consisting of 22 nymphs and 10 adults had succumbed.

In another room, most of the bugs were alive at 8 A. M. of the first day when the temperature had reached 108 degrees. At 1 P. M., with the temperature at 111 degrees, a few were found paralyzed; at 5 P. M., with the temperature at 114 degrees, all were apparently dead and the box was then removed. Several days later, the contents of the box was re-examined. At this time, 6 nymphs and 5 adults were dead but 3

[1]According to C. L. Marlatt, U. S. Farmers' Bulletin 754, p. 5, 1916, the eggs of the bedbug "hatch in a week or ten days in the hot weather of midsummer."

nymphs were found to be alive, though paralyzed. Twelve days after removing from the heated room, the contents of the box were again examined and all were found to be dead, the paralyzed nymphs having failed to recover.

In another room with a temperature of 99 at 8 A. M. of the first day, killing had commenced before 1 P. M., when six were found dead with the thermometer at 104 degrees, but was not complete until 5 P. M. of the second day, the intervening temperature readings being 106 at 5 P.M. of the first day, 106 at 8 A. M., 108 at 1 P. M., and 108 at 5 P. M. of the second day.

In still another room with a temperature of 95 degrees at 8 A. M. of the first day, the bugs began first to show the effects of the heat at 1 P. M., when two nymphs were paralyzed with the temperature at 100 degrees. At 5 P. M. of the same day, with the temperature still at 100 degrees, one bug was dead. At 5 P. M. of the second day, after continued exposure to temperatures attaining 104 degrees at 8 A. M., 108 at 1 P. M., and 108 at 5 P. M., all of the bugs, consisting of 2 nymphs and 3 adults were dead.

Up to the present time, December 27th, 1924, not a single complaint about bedbugs has been received from any of the rooms that were treated in these two experiments, although the rooms have been occupied almost continuously, and some of them have been carefully inspected.

From these experiments, it has been concluded that bedbugs can be satisfactorily controlled by heating the infested rooms to a temperature somewhat above the usual maximum summer heat. Killing by superheating begins at as low a temperature as 100 degrees Fahrenheit, and is accelerated by higher temperatures. Total mortality can be secured in a few hours' exposure to 120 degrees. A very high percentage mortality can be secured at as low a temperature as 110 degrees when maintained for two days. Nymphs and adults are destroyed with equal readiness, and this is apparently also true of the eggs. Bugs located between thick mattresses survive much longer than those located on beds or upon the floor.

Killing bedbugs by superheating presents many advantages over fumigation or treatment with contact insecticides. The labor outlay is much less, since it is not necessary to seal cracks and keyholes, place fumigants, or handle furniture. It requires no expert manipulation as is the case when fumigating with hydrogen cyanide, but can be managed by the regular organization of hotels, hospitals and dormitories, or by the residents of houses without calling in outside assistance. It is safe;

a condition rarely, if ever, the case with the highly poisonous hydrocyanic-acid gas, an advantage which makes its use possible in sections of an occupied building without risk to occupants of other sections. Its use does not necessitate the purchase of extra materials or equipment. It possesses further advantage over fumigation in that the results may be determined at any time during the treatment by room to room inspection, it being possible to inspect rooms at temperatures at least ten degrees higher than the very effective temperature of 120 degrees Fahrenheit, for short periods of time without excessive discomfort. The method seems to be particularly suitable to hotels, hospitals, dormitories and similar buildings housing a large number of beds, and which are heated by steam or hot water from a central plant, or to dwelling houses heated by furnaces. In degree of penetration, this method equals fumigation at its best and is far superior to hand applications of contact insecticides.

In the dormitories at the Mississippi A. & M. College, where fumigation with hydrocyanic-acid gas has been used for many years previous to this summer, the superheating method has proven in two extensive tests, to be cheaper, safer, more effective than fumigation and a much more desirable form of treatment in every respect.

Under ordinary conditions, this method of treatment will be most effective when undertaken during hot, midsummer weather, when the outside temperature is sufficiently high for the heating plant to readily elevate the inside temperature to about 120 degrees Fahrenheit. Unless the source of heat is considerably in excess of maximum requirements, it will not be feasible to use this method during the colder winter months.

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MR. G. A. DEAN: Mr. President, while there are several records of heat having been used for the control of household pests in houses of two or three rooms or eight or nine rooms, in so far as I know, this is the first instance we have had where heat has been used successfully in the control of household pests in large dormitories or buildings used for dwelling purposes.

The rapidity, of course, with which a room can be heated or the killing temperatures reached, depends upon the amount of radiation. I mention this simply because it seemed to me it is reasonable to expect that this far north and particularly still farther north there must be nearly twice the amount of radiation in a house to keep it warm during the winter as they would have in the South. If this is true, and we get here in Washington, a temperature of 95 or 98 degrees, and in many of our

states, even as far as Minnesota, we may get a temperature of 100 degrees, where the air is much drier than in the South, it means that we can reach these killing temperatures in less time than Professor Harned has in the building described in his interesting paper, and thus it would make it a more practical method of control than it has been considered heretofore. This would seem to be a very practical means of control.

MR. L. O. HOWARD: Mr. President, Dr. Dean is undoubtedly right in his preliminary statement. Experiments with heat on a large scale have been carried on in several parts of the world but they have not been under scientific supervision. Neither have the results been analyzed in a very clear way, as Professor Harned has analyzed his experiments. They are, therefore, very valuable.

I have never been at the Agricultural College of Mississippi, but I had the pleasure of meeting a group of Professor Harned's former students a year and a half ago at Gulfport at a dinner, and I saw the extraordinary love and admiration that they have for him. But it seems to me, assuming that this large dormitory could not have become naturally infested by bedbugs, that it must have been a part of a large experiment of introducing bedbugs in which the whole student body was concerned. From that point of view, it strikes me as one of the most extraordinary pieces of cooperation on record. (Laughter.)

MR. G. A. DEAN: If I may just take another moment, I would like to add I do not believe the heating would be successful in houses that have the hot water heating system. Some experiments have been carried on in this respect, and have not proved effective. While killing temperatures may be had in houses heated with hot air, and also, of course, with steam they may not be reached in houses having the hot water system, because the radiators can not be heated hot enough.

I would like to ask if there was any effect noticeable upon the woodwork? That question is often asked.

MR. R. W. HARNED: No such effect was noticed.

MR. F. C. BISHOPP: I have often wondered why it happened that there were so few bedbugs in west Texas, over a large part of that country, as compared with some of the more northern regions. I think that Professor Harned has explained that, because we often get temperatures well above his minimum killing temperature.

I just want to ask one question and that is in regard to the effect on the eggs. Did you get any exact record as to what effect the heat had on the eggs?

MR. R. W. HARNED: That is in the paper. We examined all the rooms for eggs and made records of those rooms; we went back to them several times and could not find that any had hatched.

MR. G. A. DEAN: Mr. President, May I make one further remark? If one has traveled in the Yuma Valley of Arizona, or the Imperial Valley of California, or in Western Texas, he knows that bedbugs are practically unknown, or at least do not last very long in hotels and dwelling houses. On some occasions I have slept on beds in adobe hotels where you might expect to find bedbugs, but they were not present. The heat, or high temperatures, of these districts has killed them, or prevented them from becoming established.

At this point Third Vice-President E. R. Sasscer assumed the chair.

VICE-PRESIDENT E. R. SASSCER: The next paper is by M. C. Hall.

## THE OCCURRENCE OF CUTEREBRID LARVAE IN DOGS AND CATS, AND THE POSSIBLE MODES OF INFECTION

By MAURICE C. HALL, *Zoologist, Zoological Division, Bureau of Animal Industry, Washington, D. C.*

Cuterebrids of the genera *Cuterebra*, *Bogeria*, *Rogenhofera* and *Atrypoderma* are normally parasitic in mammals of the orders Rodentia and Lagomorpha, but there is sufficient evidence available at present to warrant the belief that the occurrence of cuterebrids in carnivores is not such a rare thing as is commonly supposed.

The records of cuterebrid larvae from cats have been summarized by Hall in papers in 1921, 1922 and 1924, the last paper showing that they have been recorded in 14 definite cases with an indefinite number of additional cases mentioned. Two additional cases may be added to these records. Dr. H. J. Milks has recently sent in a specimen from a cat at Ithaca, New York, with the statement that these grubs are not especially rare in cats, a few cases occurring at Ithaca every summer. Dr. H. B. Raffensperger has also reported to me a case of an infested kitten at Wheaton, Illinois, observed by Dr. Harry Caldwell. To these 16 definite cases must be added an indefinite number which, judging from Dr. Milks' statement that a few cases occur at Ithaca every summer, must make a fairly large total.

Up to the present time only two cases of cuterebrid larvae in dogs have been reported, these including French's case from Canada and Crawley's case from Pennsylvania. The following additional cases are added here:

A cuterebrid larva, apparently belonging in the genus *Bogeria*, was collected this fall from under the skin of a pup three weeks old at Whea-

ton, Illinois, by Dr. Caldwell and sent to Dr. Raffensperger who transmitted it to the Zoological Division. The specimen is a little over 1 cm. long, about 5 mm. wide and equally thick. In addition to this case it may be added that Dr. J. V. Lacroix tells me that he has had at least four cases of these grubs under the skin of dogs, always in the throat region, in his veterinary practice at Evanston, Illinois. The total number of cases from the dog, therefore, is at least seven. Undoubtedly an even larger number of cases have been observed and never recorded.

The manner in which cats and dogs become infected is still problematical, as no experimental observations or actual observations of infection in nature have been made. However, there are certain obviously possible and probable explanations. An explanation for at least some of these cases was made casually and without discussion by Hadwen in 1915 to the effect that a cat might be infected by eating an infested squirrel. Partial evidence in support of this idea may be found in the experiments reported by Parker and Wells in 1919 as to the probable mode of infection in the mammal hosts. These authors fed larvae obtained from the eggs of *Cuterebra tenebrosa* to prairie dogs and obtained infections, indicating that the usual subcutaneous infestation will follow from swallowing these young larvae. Ferris has noted that the eggs of *Cuterebra americana* hatch spontaneously without such stimuli as moisture, friction or heat and that the first-stage larvae are extremely active. It appears quite probable that these larvae would be swallowed by host animals in licking themselves and possible that the movements of the larvae on the skin would cause sufficient stimulation to cause the host animals to lick the involved areas. Crawley states that Dr. Aldrich has suggested to him in correspondence that dogs and cats become infected with cuterebrids by eating rodents or rabbits containing young cuterebrid larvae. This explanation appears to be sound and reasonable and is the probable explanation for some cases, assuming that young larvae, such as those which are migrating through the tissues, might, when swallowed, take up their migrations again from the digestive tract to their position under the skin. Actually, this point requires experimental verification.

This explanation does not exclude the possibility that cuterebrid flies occasionally oviposit on cats and dogs with resultant infestation with larvae in these hosts. In the case reported here of infestation in a pup three weeks old the evidence points to direct infection by the fly rather than to infection as a result of the pup eating part of a rabbit or rodent infested with the grub. In the experiments with *Cuterebra tenebrosa*

reported by Parker and Wells, the grubs first appeared under the skin in 9 to 12 days after infection by mouth, the skin was punctured two days later, and the grubs emerged 37 to 47 days after infection. The occurrence of the grub in a pup three weeks old as a result of infection by the fly would fit in with these periods in the life history of the fly, assuming that the pup was infected during the first week of its life. On the other hand, the likelihood that a pup, which does not open its eyes until it is nine days old and nurses until it is about six weeks old, would eat part of an infested carcass during the first week of its life is almost too remote for consideration. The cases of cuterebrid larvae reported from kittens are also more likely to be cases of infestation resulting directly from the fly than from eating infested carcasses. There is no serious objection to the assumption that a rabbit bot fly under certain circumstances might oviposit on a dog or cat. The ox bot flies, *Hypoderma* spp., occasionally oviposit on and produce larval infestations in horses and persons, suggesting that flies as well as human beings, may make mistakes at times or perhaps may take what is available in lieu of what is desired.

The possibility of prenatal infection may be noted in passing, as it is becoming more evident all the time that in the case of parasites with larvae having the habit of wandering through the host tissues the likelihood of prenatal infection is considerable. As yet we have no evidence of such a case in cuterebrids, and only a case of subcutaneous infestation very early in life or a carefully controlled laboratory experiment would establish the existence of such infection.

The occurrence of a last-stage larva of a cuterebrid in the nostrils of a cat, reported by the writer in 1921, appears to be a special case requiring a sort of explanation not given above. There is a possibility that the grub entered the nostrils of the cat as the cat ate an infested carcass or bit at an infested area on the cat itself, and this appears to be fairly probable. There is also the possibility that a grub infesting some portion of the cat's head entered the nostrils in an attempt to migrate out.

Some first-hand evidence showing that carnivores swallow cuterebrid larvae in eating infested hosts came to the writer's attention during the past year. In one case a late-stage larva of a cuterebrid was sent in by Mr. S. W. Greene of McNeill, Mississippi, with a report to the effect that it was passed by a dog. In another case, Miss E. B. Cram of the Zoological Division collected a third-stage larvae from the stomach of a coyote killed at Black Rock, Utah. In the case of a well developed larva, presumably one that has undergone any degree of development

under the skin, the grub probably passes, alive or dead, through the digestive tract of the carnivore without migration, and only very young larvae would be capable of again taking up their migration to the skin.

The subject of cuterebrid larvae in dogs and cats has more than merely scientific and academic interest. Many of these cases are taken to veterinarians for treatment and Miss Sharp, in a paper by Osborn, has reported these grubs as the cause of death in a cat. The evidence summarized here indicates that these grubs are fairly common in dogs and cats and deserve some study in connection with these domesticated animals.

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VICE-PRESIDENT E. R. SASSCER: The next paper is by T. H. Frison.

## INTESTINAL MYASIS AND THE COMMON HOUSE-FLY (*MUSCA DOMESTICA* LINN.)

By THEODORE H. FRISON, *Natural History Survey, Urbana, Ill.*

ABSTRACT

Authentic published records of the common house-fly being the cause of intestinal myasis of man are not frequent. A case of intestinal myasis caused by the larvae of the house-fly was observed at Champaign, Illinois, in September, 1924, in a boy recovering from an attack of pneumonia

A brief survey of the general and more important treatises which consider the subject of intestinal myasis will reveal that little data have been secured, or at least published, which incriminate the larvae of the common house-fly in this connection. Instances in which the larvae of the common house-fly have been reported as passed in the vomit or feces of man are not rare, but except in a very few cases no great reliance can be placed in the correctness of the specific identifications as reported. Riley and Johannsen (1915) in their *Handbook of Medical Entomology* summarize the situation in regard to the house-fly and intestinal myasis very well by saying that "while such cases may occur, it is probable that in most instances similar appearing larvae of other insects have been mistakenly identified." The records published in 1912 by Austin, an English worker in the fields of Medical Entomology and Diptera, give us two instances, among others, where the identification of the house-fly larvae from the alimentary tract of man rests upon a secure foundation. Doubtless, such cases are much commoner than the literature at the present time would indicate.

The past fall there came to my attention a case of intestinal myasis in which the larvae of the common house-fly were involved, and because of

the infrequency of published authentic records of this nature the following brief account is presented. One of the physicians in the City of Champaign, Illinois, came to me about the middle of September with some larvae which had been passed in the vomit of a sixteen year old boy. The boy who passed the larvae was at the time very slowly recovering from a severe attack of pneumonia and the finding of these larvae, which were noticed in the vomitus on the bed as soon as passed, aroused his suspicion that they might possibly be responsible for the slow recovery of his patient and earlier complications in the case.

Aware of the destructive and painful work of the larvae of the screw-worm fly in the frontal sinuses and head cavities, I had more than a passing interest in making an immediate and critical study of the larvae and the case in general. The result was that I found the larvae, less than one-half grown, to be those of the common house-fly and no measures were taken to remove any other fly larvae that might remain in the boy other than the administration of a strong laxative. I may add that the same day that the larvae were passed with the vomit, a large number of them were also reported to have been passed in the feces. If the screw-worm fly had been involved in this case more severe measures would have been necessary, since the condition of the boy would have offered the screw-worm larvae a very favorable opportunity of claiming a victim. Some time after this happened Dr. O. A. Johannsen, of Cornell University, spent a couple of days in my office studying Chironomidae and he confirmed my identification of the larvae.

As in most or almost all cases of this nature there is no exact means of determining how the infection occurred. It seems most likely, however, that the eggs or young larvae were ingested with food. I was told by the physician that the boy also had trouble with nasal catarrh and as a result had a very bad breath and during his sickness breathed a great deal with his mouth open. Considering the sick condition of the boy it is not altogether impossible that the eggs were deposited directly in the mouth and consequently swallowed. I may add that the sanitary conditions in the home of the boy were not of the best and flies had almost free access to the sick room.

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MR. L. O. HOWARD: Mr. President, these cases are by no means so rare as the speaker's mention of the literature would seem to indicate. The Public Health Service and a number of the state Boards of Health in different parts of the country make a practice of referring all such specimens to Washington for accurate identification. Therefore, be-

ginning with the time when Nathan Banks was with us, and continuing on with Dr. Aldrich, and especially Mr. C. T. Greene, who is making a most careful study of the morphology of muscid larvae, we have had, I imagine, not single cases, not dozens of cases, but scores of cases, in the last ten or twelve years, of intestinal myasis caused by the common house-fly. There can be no question as to the identification of the specimens on account of this careful study that has been made of the larval and pupal characters.

VICE-PRESIDENT E. R. SASSCER: We will proceed to the next paper.

## REPELLENTS AND LARVICIDES FOR THE SCREW WORM AND OTHER FLIES

By F. C. BISHOPP, R. C. ROARK, D. C. PARMAN and E. W. LAAKE,
*U. S. Bureau of Entomology, Dallas, Texas*

(Withdrawn for publication elsewhere)

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MR. E. G. KELLY: I would like to ask Mr. Bishopp a question. First, I would like to say that lime sulphur solution has been sold in cans in unlimited quantities, very dilute at that. I know of one firm who bought a barrel of lime sulphur and made over 4,000 three-ounce bottles, which they foisted on the public at a dollar a bottle. That is a pretty good profit. (Laughter.)

We have had an awful time trying to get our farmers to quit buying that stuff. I would like to ask why it is that they are allowed to make and sell that stuff under our Federal quarantine and Federal or state regulations.

MR. F. C. BISHOPP: Mr. President, I believe some of the members of the Insecticide Board are here. Perhaps they can make a reply to that.

VICE-PRESIDENT E. R. SASSCER: Dr. Abbott, can you answer that question for us?

MR. W. S. ABBOTT: I might say in answer to that, that the Insecticide Board is doing everything it can to stop the sale of these materials. I think I can safely say that we have brought action against every manufacturer that we have been able to find selling this material in interstate commerce. If the material is manufactured and sold in the state, it cannot be touched by the Federal Law in any way, but every manufacturer who has shipped his material into a state where we have been able to collect samples has received notice from the Board.

We have a large number of cases pending in the court now. We have in some instances three and four cases against one manufacturer, all

pending in the courts. We have seized numerous shipments. We have ample evidence to push these cases and to win them, but the trouble is that Federal courts are very crowded and it is very difficult for us to bring our cases to a head on that account. We have the samples collected; they have been analyzed and tested and we are doing all that we can to stop their sale. The Board has published notice to the effect that it has found these materials inefficient, which notice has had rather wide circulation, and we are doing all that we can to stop the sale of them.

VICE-PRESIDENT E. R. SASSCER: The first paper under the heading of Insects Affecting Forest and Shade trees is by S. A. Graham.

## TWO DANGEROUS DEFOLIATORS OF JACK PINE

By S. A. GRAHAM

ABSTRACT

Jack pine, *Pinus banksiana*, once regarded a weed tree, is now becoming a valuable timber species. In the past this tree has been considered almost immune to insect injury but recently it is suffering from the attack of several defoliators. This paper is a preliminary report of cooperative projects concerning two of these defoliators, the jack pine sawfly, *Neodiprion* n. sp., and the spruce budworm, *Archips fumiferana* on jack pine. The study is being conducted jointly by the Bureau of Entomology, United States Department of Agriculture and the Minnesota Agricultural Experiment Station.

Climatic conditions influence the abundance of these defoliators but they are not of sufficient importance to explain the present outbreak. Neither is there evidence that the outbreak has been made possible by a lack of parasites and predators. As a result of lumbering and fires the quantity of jack pine forest has been tremendously increased thus making food conditions especially favorable for jack pine insects. This appears to be a very important factor in making possible this outbreak.

Studies of control are still in progress and recommendations at the present time are purely provisional. Spraying with arsenate of lead is effective and is recommended for valuable trees. In forests, natural agencies and forest management must be relied upon for the control of these pests. Regulating the cut so as to favor other species than jack pine is recommended, in order to produce a safer balance in the forest.

Today our virgin forests of white and norway pine are almost gone, and each year sees more of our inferior species of trees coming into use. While our supply of norway pine, *Pinus resinosa* Ait, and white pine, *Pinus strobus* Lin., was abundant in the Lake States, jack pine, *Pinus banksiana* Lamb., was regarded as a worthless weed tree in our forests. As our forests were cleared and burned this species has gradually come into its own. With jack pine pulpwood now bringing $12.00 per cord at the mill, and with a steadily increasing demand for all jack pine products, this once lowly species is looked upon with much favor. It is upon jack pine that we must depend to a large degree to tide over the period of

timber shortage that will soon be upon us. This species is an ideal lumberman's tree. It reproduces prolifically, grows rapidly, and is fire resistant. Because of these characteristics much of the land once occupied by white and norway pine has grown up to pure jack pine. In addition to its other good qualities, jack pine has been regarded in the past as being a tree very resistant to insects and diseases.

But in the last few years we have begun to realize that this tree is not so immune to insect attack as we once believed it to be. A few years ago the pine tussock moth, *Olene leucophaea*, A. & S., appeared in the jack pine region of Wisconsin, and before the epidemic had run its course the jack pine over extensive areas was severely injured and many of the trees in some localities were killed outright. During the last three or four years another defoliator has become epidemic upon the jack pine in certain sections of the State of Minnesota. A sawfly, *Neodiprion* n. sp., that we will call the jack pine sawfly, has appeared in epidemic numbers and, as a result of repeated defoliation the trees in the infested localities are beginning to die. Now a third dangerous jack pine defoliator has become active; the spruce budworm *Archips fumiferana* Clem., or at least a biologic variety of this species is now present in epidemic numbers in certain localities of Minnesota, Michigan, and probably Wisconsin and is already killing trees as a result of repeated defoliation.

Investigations concerning both the sawfly and the budworm are now being conducted co-operatively by the Minnesota Agricultural Experiment Station and the Bureau of Entomology, United States Department of Agriculture. This paper is a preliminary report of these projects.

One of the most important considerations in undertaking such a problem as this is the determination of the factors involved in making epidemic conditions possible. Not until we know the cause of an outbreak can we hope to prevent future similar outbreaks. In this instance we are dealing with native insects that have been innocuous or at most only slightly injurious for generations. We are dealing with insects that have a fair number of parasites working upon them. Under the conditions existing previous to the advent of the lumberman these pests did little or no damage. Under present day conditions they have become epidemic. Let us see what changes have taken place in the environment of these insects that may have made conditions more favorable for their multiplication.

First, let us summarize these factors or groups of factors that might have an influence upon the abundance of these pests. The most important of these may be listed as follows:

1. Weather conditions.
2. Parasites and predators.
3. Food supply.

We know that the weather runs in cycles and that all plants and probably all animals are affected favorably or adversely by weather fluctuations. But we have no evidence to indicate that climate of today is essentially different from the climate of a few centuries ago. If weather were the controlling factor of the sawfly and bud worm epidemics, then we should expect to find some evidence that at corresponding points in previous cycles, outbreaks of these insects occurred. There have been no previous outbreaks of these pests recorded in jack pine, but because of the inadequacy of our entomological records, we cannot assume positively that there have been none. In the course of our life history studies of the sawfly, however, it has become evident that, like other insects, its rate of development is much influenced by the weather. Also, examination of the annual ring picture of old jack pines shows periods of reduced growth which may represent times when defoliators such as these were abundant. There is, however, no biological evidence that such a severe epidemic as the present one has occurred during the last tree generation. It would appear, therefore, that although weather conditions probably have an influence upon the abundance of these pests, other factors are more important in explaining the severity of the present outbreak.

Neither do we find any dearth of parasitic species preying upon the pests. Several species of hymenopterous parasites have been reared from the sawfly, and the tip moth is parasitized by several of the Hymenoptera and at least one Tachinid. Also, both insects are quite commonly attacked by entomophagous fungi, and the sawfly is susceptible to an epidemic disease similar to the polyhedral disease of lepidopterous larvae. Therefore, we cannot ascribe the outbreak to a lack of parasites.

When however we consider the factor of food we find that a very striking change has taken place during the last half century. As a result of logging and fires the jack pine has come to occupy much of the area once covered by mixed forest of norway and white pine, so that in addition to the original areas of jack pine forest we now have vast areas of pure jack pine on white and norway pine land. Hence we have mile upon mile of forest areas covered with but one species. Thus because of the abundance of jack pine the search for food has become easy and safe, and food has therefore ceased to be a limiting factor. It is difficult to avoid the conclusion that the increased quantity of jack pine is of primary importance in making possible outbreaks of such defoliators as the sawfly and the tip moth.

The change in forest type described above, has probably had its effect upon bird life. We know that in the virgin white pine forest with its varied flora we usually find a greater variety of insectiverous birds than in the pure jack pine stand. Reasoning by analogy we may conclude that there has in all probability been a reduction of the bird fauna in this region, a change favorable to the multiplication of defoliating insects.

The foregoing statement of the probable causes leading to these outbreaks must be regarded as provisional. At a later time when the projects now under way are finished, a more complete and positive statement of the situation will be made.

Having considered the probable causes leading up to these outbreaks, we will now pass to a consideration of the activities of the insects under the conditions existing at present.

## Habits and Life History of the Jack Pine Sawfly

The jack pine sawfly attacks trees of all ages but appears to prefer the older trees. Frequently young stands in the heart of the infested area are practically untouched. The larval feeding habits are very distinctive. They appear early in the spring and feed only upon the old needles. Frequently all of the old needles may be destroyed before the new growth has started. Under such a circumstance the trees may appear to be completely defoliated in June, and later in the season when the new needles have expanded the trees will appear almost normal to the casual observer. After defoliation by the sawfly the foliage appears thin, and the needles are tufted on the tips of the twigs. After two years of defoliation of this sort the weaker trees will begin to die, and continued defoliation will kill the most vigorous individuals.

The life history of the sawfly may be briefly summarized as follows: The adults appear in September and insert their eggs in slits cut in the edges of the needles. These eggs pass the winter and hatch the following May. Under favorable conditions the larvae develop rapidly and reach the fifth and last instar before the middle of June. When full grown the larvae drop to the ground and spin their cocoons in the litter beneath the trees. A part of these larvae pupate and transform to the adult in late August or early September of the first year. These adults emerge and deposit eggs the same fall. A part of the larvae, however, fail to pupate the first autumn but pass the winter in the prepupal condition within the cocoons. These over-wintering larvae do not emerge until the following September. Thus a part of each generation remains dormant within the cocoons for over a year. This characteristic results in

giving each generation two chances of experiencing a season favorable to its development, and is a very important factor in safeguarding the species from disaster.

The importance of this characteristic was particularly emphasized during the season just passed. During late May and early June weather conditions were very unfavorable to larval development. The weather was cold and on the fifteenth of June the larvae had only reached the end of the first instar. This was abnormally late. During the first instar predatores and accidents of one sort and another reduced the number of larvae fifty per cent. Following the fifteenth of June there was a week or more of favorable weather, with the result that the larvae developed rapidly with only slight reduction in numbers. Then came several cloudy or rainy days when the humidity was high. Suddenly, without warning an epidemic of a disease similar in character to the polyhedral disease of lepidopterous larvae broke out and in a few days almost wiped out the sawfly larval population. From about five thousand larvae in our experiments less than fifty remained at the end of the epidemic,—a reduction of over 99 per cent. Judging from the counts made in the forest there was a similar mortality in their natural environment. Under such conditions as these that portion of the brood which has been lying dormant since the previous season becomes an exceedingly important factor. Although very few *new* cocoons could be found in the woods in July, an abundance of eggs were deposited in September by the portion of last year's generation holding over.

## Habits and Life History of the Spruce Bud Worm on Jack Pine

Like the sawfly the bud worm also prefers large trees. In some instances young pines are severely injured but in such cases these young trees are always near larger trees. Unlike the sawfly this pest attacks only the new growth.

The eggs are deposited upon the needles during early August and hatch during the later half of that month. The larvae, without feeding, seek out protected places on the trees and hibernate until the new growth starts in the following June. Then they emerge and begin feeding upon the succulent needles and stems of these new shoots. They web the needles together more or less and live under the protection of this light web. During the past season pupation took place between the fifteenth and the twenty-fifth of July, the moths emerged between the twenty-fourth of July and the seventh of August, and the eggs began hatching about the twentieth of August. When we consider the abnormally cool

season it is quite probable that the bud worm, like the sawfly, was somewhat retarded in its development, and that in the average year they might reach full development at an earlier date.

## Possibilities for Control

It is too early in the course of these investigations to make specific and definite recommendations for the control of these insects. But, naturally, as the work progresses control possibilities will be brought out. Several leads have already opened up and are being investigated. It is possible at this time, however, to make a few general statements.

The effectiveness of spraying with powdered lead arsenate was definitely proved during the season just passed. By using this poison at the rate of three pounds of the powder to 50 gallons of water, the proprietor of a summer resort, with our assistance, was able to clear the trees about his buildings of the sawfly larvae. The work was done in June while the larvae were still small. Although the apparatus available was far from adequate the treatment was a decided success. Incidentally, the tip moth that appeared in surrounding groves did not show up on the sprayed trees and was presumably controlled by the spraying. Spraying, therefore, is to be recommended for the protection of valuable trees.

In the forest, of course, we must depend upon forest management and natural agencies for the control of these pests. A reduction of the quantity of jack pine must be accomplished, and other species of trees must be favored on suitable sites in order to produce a more balanced condition in the forest. This balance makes for safety, it reduces the chances of serious outbreaks, and it should therefore be continually kept in mind during logging operations.

## Summary

1. Jack pine, *Pinus banksiana*, once regarded a weed tree, is now becoming a valuable timber species.

2. In the past this tree has been considered almost immune to insect injury but recently it is suffering from the attack of several defoliators.

3. This paper is a preliminary report of cooperative projects concerning two of these defoliators, the jack pine sawfly, *Neodiprion* n. sp., and the spruce bud worm on jack pine. The study is being conducted jointly by the Bureau of Entomology, United States Department of Agriculture and the Minnesota Agricultural Experiment Station.

4. Climatic conditions influence the abundance of these defoliators but they are not of sufficient importance to explain the severity of the present outbreak.

5. Neither is there evidence that the outbreak has been made possible by a lack of parasites and predators.

6. As a result of lumbering and fires the quantity of jack pine forest has been tremendously increased thus making food conditions especially favorable for jack pine insects. This appears to be a very important factor in making possible this outbreak.

7. The eggs of the jack pine sawfly are laid in the fall. The larvae hatch in the spring and develop rapidly. They feed only on the old growth. Cocoons are spun in the litter beneath the trees and a part of the brood emerges and oviposits in September following cocooning, but a portion does not emerge until over a year after cocooning. This protects the species to a great degree against calamities.

8. The eggs of the spruce bud worm are deposited on the needles in early August. These eggs hatch in a short time and the young larvae, without feeding, go into hibernation. They emerge in the following June and feed upon the new growth. Pupation takes place about the middle of July and the adults emerge in late July and early August.

9. Studies of control are still in progress and recommendations at the present time are purely provisional.

10. Spraying with arsenate of lead is effective and is recommended for valuable trees.

11. In forests, natural agencies and forest management must be relied upon for the control of these pests. Regulating the cut so as to favor other species than jack pine is recommended, in order to produce a safer balance in the forest.

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PRESIDENT A. F. BURGESS: I would like to ask Mr. Graham a question in regard to the effect of disease on sawfly larvae. I think he stated that there was a mortality of ninety-nine per cent. Just how was that figured? What method did you use?

MR. S. A. GRAHAM: We were running experiments with the sawfly larvae under different environmental conditions, and in those experiments we had about 5,000 larvae, and from those 5,000 larvae with which we started in the spring we had less than fifty cocoons. The remaining larvae died. That gave us a fairly positive figure under experimental conditions.

At the same time we were making counts on trees in the forest, count-

ing the loss from day to day due to disappearance of the larvae, and apparently the same condition existed in the woods as existed in our experiments.

PRESIDENT A. F. BURGESS: We have had in connection with gipsy moth work from time to time serious outbreaks of disease, and it has been a very difficult thing to figure any definite percentage basis of mortality. Of course, the cage records that we have had on that work do not compare very well with the conditions that you get in the open. The mortality is always higher in the cages with us with that insect than it is in the field.

MR. S. A. GRAHAM: I might say in explanation that these experiments we were carrying on were not cage experiments, but were jack pine branches that were placed under different environmental conditions, different shade conditions, and the insects were actually in the open; they were not in cages.

MR. HENRY FOX: I would like to ask Mr. Graham about the results in regard to mortality that he got under the different environmental conditions.

MR. S. A. GRAHAM: The mortality was so high, it would be impossible to make comparisons. It was almost equally complete under all environmental conditions. I should say that, offhand, possibly the condition of one-half shade was the most favorable for the insect. It had the smallest amount of injury under that condition. But the number surviving were so small that it would really be unsafe to make a definite comparison.

PRESIDENT A. F. BURGESS: I would like to ask one more question: whether Mr. Graham can tell us if this disease has been determined, what type of disease it is, whether it is fungus, bacterial, protozoan, or what?

MR. S. A. GRAHAM: That is a very difficult question to answer because the disease arose rather unexpectedly and before we got the material to the proper authorities for identification it was ruined. I did get some larvae to Dr. W. A. Riley but he was unable to get any satisfactory determinations of them.

Judging simply from the symptoms of the larvae, they appeared to be very similar to the symptoms shown by lepidopterous larvae as a result of bacterial wilt disease, but whether it was that disease or something else cannot be stated definitely.

VICE-PRESIDENT E. R. SASSCER: Before proceeding with the next paper I should like to ask Mr. Graham if this sawfly is presumed to be a native species or may it possibly have been introduced?

MR. S. A. GRAHAM: So far as we know, it is a native. We have no reason to believe that it is an introduced species.

VICE-PRESIDENT E. R. SASSCER: The next paper is by C. W. Minott and I. T. Guild.

## SOME RESULTS OF THE DEFOLIATION OF TREES

By C. W. MINOTT and I. T. GUILD, *Gipsy Moth Laboratory, Melrose Highlands, Mass.*

ABSTRACT

Aside from killing of trees by defoliation there is a loss in growth of those that survive. This has been measured accurately for many New England species defoliated by the gipsy moth *Portketria dispar*. Observations extending over ten years are summarized and indicate that loss in growth is roughly proportional to the degree of defoliation. In the period nearly one-half of the oaks died and the survivors lost on the average more than one-third of their foliage and growth annually.

It is an accepted fact that the loss of foliage deranges the vital functions of tree growth, but to what extent and how, may not be so clear. Of course some species produce a crop of timber more rapidly than others and varying conditions influence the rate of growth of each species. Any influence which checks the growth of timber may be accepted as an economic loss. An attempt to measure such loss has been made in connection with the gipsy moth studies in New England; but only a beginning has been made in arranging and analyzing the great mass of statistical information bearing upon this subject. For grouping, averaging, and correlation in pairs, something like 400,000 independent observations are available. Some of the results thus far obtained may be worth presenting at this time.

Individual records have been made covering 10 years (1912–1921) for 14,610 trees, comprised in 37 species, distributed over an area in New England of about 4,000 square miles included in the region infested by the gipsy moth in 1911. Furthermore, to give a more accurate measurement of growth, increment borings were made of 422 trees from which thin sections were cut for microscopic measurement of annual rings.

Defoliation varies in different species, years and localities according to the food preference of the caterpillars and their abundance. As a result of food preference, trees have been divided into four classes; class 1 favored food, class 2 not favored by young larvae, class 3 partially favored, and class 4 unfavored.

It is found that of 17 favored species (8,584 trees) the average defoliation per year was 33.6%; of five species in class 2 (mostly conifers)

8.8%; of ten species in class 3, 10.2%; and four species in class 4, 1.9%. In individual trees and single years this percentage varied from 0 to 100%.

The fact that young larvae seldom feed upon coniferous trees partly explains the low average defoliation given for class 2. For full discussion of food preference see U. S. Department of Agriculture Bulletin No. 250, Food Plants of the Gypsy Moth in America by F. H. Mosher.

These figures are interesting as indicating the actual injury to tree growth. The average yearly loss is comparatively small except in the favored food class. But this class makes up a large part (probably more than half) of the woodland in the infested region. If it is true, as reasonably can be claimed, that the observed trees were fairly representative of the distribution of species and moth injury throughout the area, then the favored food trees as a whole lost an average of one-third their foliage every year, and this is surely a serious loss.

It is of particular interest to determine the effect upon growth of different degrees of defoliation and also of repeated defoliation. Studies for this purpose have been made of all the species, and as would be expected, the most marked effect of defoliation is shown in the trees of class 1.

Among the trees of class 1 the oaks are at once the most favored food, the most abundant in the infested region, and, next to the white pine, are of the greatest economic importance. Red, scarlet, black and white oak taken together lost, on the average, 36.5% of their foliage per year; and in the ten years 47% of the trees died; while the growth of wood was only 62% as great as that of the previous decade, a loss of 38%.

It is found that growth declines as defoliation increases, in practically constant ratio. Measurement of 2510 annual rings, representing ten year's growth of 251 oaks, showed 23.7% decline in the years of no defoliation, and 52.2% in the years of 100% defoliation, while intermediate percentages agree closely with the same ratio. As already stated, the average defoliation for all observed oaks, (5,466 trees) was 36.5% per year, which, by the same ratio would call for 34% decline. The actual decline was found to be 38%, a difference of only 4%. It is, therefore, safe to assume that this ratio is reasonable close to the true value, and it can then be roughly stated that with oaks of New England an average loss of one-third the foliage per year results in a loss during a ten-year period of one-third the normal diameter growth of timber.

In addition to trying to measure loss in growth, tentative studies have been made to determine how much injury trees will stand, but they

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EFFECT OF GIPSY MOTH DEFOLIATION UPON GROWTH OF OAKS

1.—Cross section of white oak about 40 years old showing checked growth in last 14 years. 2.—Increment boring of white oak with diameter growth of 36.3 mm. from 1902 to 1911, and 11 mm. from 1912 to 1921. 3.—Increment boring of scarlet oak showing diameter growth of 51 mm. from 1902 to 1911, and 14.2 mm. from 1912 to 1921.

have not yet been carried far enough to be conclusive. About half the dominant white oaks were dead the next year following a complete defoliation, with a varying percentage of mortality after two, three and four strippings, while one tree has been found apparently well and thriving after five complete strippings. There is evidently great individual variation in the power of resistance and resiliency in different trees.

Likewise it has been impossible to separate the mortality caused by gipsy moth feeding from that caused by crowding and suppression. While loss by suppression of 20 to 30% in stands 40 or 50 years old is a high mortality rate, it is readily seen that the 47 % mortality in 10 years is excessive, and if continued at the same rate for one or two decades more, that it would wipe out the greater part of the stand. A considerable portion of this mortality is doubtless due to gipsy moths and must be added to the injury already considered, which can be measured in the surviving trees. Trees which have been checked may or may not recover normal growth. If they do recover, then the loss may be considered as that of time in maturing a crop of timber.

The continuing effect of injury, and the effect of repeated defoliation is seen in the record of years when no defoliation occurred, which shows an average decline in growth of 23.7% as compared to the general average growth of the previous decade. It should be noted particularly that the 251 trees from which these measurements were made, had survived the injury of ten years (amounting to an average of 32.5% defoliation per year) and were all dominant trees. They were also selected out of nearly 2,900 survivors especially to show the effects of defoliation, and nearly all were still rated at the end of the period as in good condition. Bearing in mind that about half their original companions had died, it is safe to assume that they represent a select class, much more vigorous and resistant than the average. The average oak would show greater decline, and 25% is a very conservative estimate for the injury in years of no defoliation as a result of the continuing effect of previous injury. Moreover, the conclusion is unavoidable that even a moderate degree of defoliation is debilitating if frequently repeated, and if continued long enough will lead to death.

The damage already noted is of two classes, temporary and permanent. In case a tree recovers its full vigor there is still a real loss from delayed growth, resulting in delayed return upon invested capital. In case of death, there is an important difference in effect upon young and old growth stands. The young trees may possibly be replaced, but those approaching maturity are a total loss unless immediately salvaged, and

the loss increases, the nearer the crop approaches maturity. Of course, judicious thinning is considered beneficial to a forest stand, but unfortunately, the gipsy moth cannot be depended on to exercise a forester's discriminating choice.

All the foregoing considerations apply with equal force to other species besides oaks, in proportion to the degree of defoliation they have suffered. White pine, for example, has, in the decade, suffered an average of 10.2% defoliation a year, and there has therefore been but little widespread damage. On the other hand, it is so susceptible to injury, that most of the trees which are completely defoliated, never recover.

The main points so far brought out by this study are that all of the important species of trees in New England have been more or less defoliated during a ten-year period, ranging from a very small percentage (unfavored food species) to an average of more than 50% a year (swamp white oak) depending upon the food preference and abundance of the gipsy moths. It is shown that 17 of the most favored food species, comprising about half the existing woodland in the region observed, have averaged a loss of one-third their foliage a year, and that this has resulted in the premature death of a considerable part of the trees. It has resulted, further, among the surviving trees (especially the oaks), in the loss of a growth of wood proportional to the degree of defoliation.

No attempt is made here to estimate the pecuniary loss resulting from this damage, but it may be said that the quantity of oak lumber produced in the United States is third in importance, only yellow pine and Douglas fir outranking it. Finally, there appears to be no reason why, with an equal degree of defoliation, the damage should not be equally severe in any oak-producing region of the country.

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VICE-PRESIDENT E. R. SASSCER: We will now proceed to the next paper by J. A. Manter.

## A PRELIMINARY REPORT ON THE USE OF CALCIUM CYANIDE FOR THE MOUND BUILDING ANT, *FORMICA EXSECTOIDES*

By J. A. MANTER, *Storrs, Conn.*

The mounds or "ant hills" built by *Formica exsectoides* are quite well known to observers in the Northeastern United States. They are found in pasture and open spaces in woodland. Trees or high bushes are never found in close proximity to these mounds because the ants kill off any growth that might shade their nest. This injury to forest trees

was not recorded as of importance until 1912. Several investigators since that time have studied the problem and Peirson in 1922 published[1] the results of his studies in which he showed how the ants were able to kill trees. The usual material recommended for the control of these ants is carbon disulphide. During the past summer I have used several insecticides, including calcium cyanide, to bring about the extermination of certain colonies of these ants working in forest plantations at the Connecticut Agricultural College. I believe that calcium cyanide will prove to be a practicable remedy.

## Injuries to Trees

The killing of trees by these ants is most noticeable and injurious in forest plantations and natural reproduction of evergreens. It is common to find cleared areas around these mounds from 24 to 36 feet in diameter in which there is no plant growth higher than about two feet. Outside of these nearly circular areas the stand of trees and bushes may be normal. The contrast between the growth inside and outside of these circles is very marked.

Early investigators believed that the ants were responsible for the death of the trees but could not explain how it was done. Fungi were commonly found but were not proven to be the causative organisms. Peirson discovered ants in the act of "squirting" formic acid into wounds that they had made in the bark. He shows that the acid coagulates[1] the cell protoplasm and thus causes a cessation of the downward flow *of* the *sap* causing the ultimate starvation and death of the tree. Both conifers and deciduous trees may be killed but the former are more susceptible to injury. I have observed their work in plantations of red and white pines, red and scotch pines, and of white spruce. At first the ants chew off some of the bark from the lower part of the trunk completely encircling it and extending a foot or more above the ground. This allows the formic acid to reach the living cells of the bark. Trees above eight feet are not often killed, probably because their thicker bark prevents the formic acid from reaching the living cells. Dead white pines show a deep constriction encircling the trunk a little above the ground with a marked swelling just above. This enlargement is caused by the continued growth made possible by the piling up of the sap at this point. On white spruce the constrictions and swellings are not so prominent. The poisoned bark becomes loosened after a few years and breaks away from the wood. The first evidence of injury to a healthy tree is a gradual yellowing of the needles on the new growth.

[1]H. B. Peirson, Journal of Forestry, Vol. XX, No. 4, April 1922.

Ants have been considered of benefit in woodland since they destroy large numbers of other insects for food but the damage done by *exsectoides* places it among the harmful forest pests. It is not uncommon for a colony of these ants to kill from 30 to 40 young evergreens about their nest. In a 6′ x 6′ triangular planting of one acre, a cleared circle of 36 feet about a mound will include 37 trees, which accounts for nearly 3 per cent of the total stand. Ant hills may average several to the acre. One observer records the killing of 75 per cent of a small plantation of white pine.

## Control

Carbon disulphide, if used liberally, will kill the ants of a colony. The method of treatment is to make holes in the mound 8 to 10 inches deep and about the same distance apart and pour into each 1 or 2 ounces of carbon disulphide. An average sized colony requires one pound or more, and for effective work the mound must be covered with a tub, wet burlap bags, or some other material. This method is costly, requires considerable labor, and a relatively high atmospheric temperature.

Calcium cyanide in the granular form has been used in these trials with very promising results. The method has been to make holes in the mounds as before, putting a small amount of the cyanide into each and filling with dirt. Two ounces for an average sized mound seems to be sufficient. No cover for the mound is necessary. Cyanide spread on top of the mound was not effective.

It is surprising to see how quickly the ants are killed when they come near this material. After seeing its deadly effect on insect life one is prompted to handle it carefully. I think the carbide odor given off by this crude cyanide serves as a warning that should help to prevent accidents. When treated mounds were dug into, some of the galleries were found crowded with the dead bodies of the ants. Usually a few living stragglers could be found. It is perhaps, too much to expect that all of the thousands of ants of a colony would be killed at once because some of them might have been away at the time of fumigation. The real test of the effectiveness of any method of control is the killing of the brood and queen as without these the rest of the colony dies. The cyanide method is not expensive. It can be applied quickly, as no special covering of the mound is necessary, and a high temperature is not needed for the production of the gas.

MR. H. B. PEIRSON: The queen is usually found at a depth, in a large nest, of six feet, so it is essential that the poison gas reach the queen at this depth. I wonder if the cyanide will penetrate that deep.

MR. J. A. MANTER: I did not dig that deep, sir, so I cannot tell.

MR. H. B. PEIRSON: How deep did you find the queens?

MR. J. A. MANTER: I did not find the queens.

MR. H. B. PEIRSON: I found at times the queens would emerge twenty or even forty feet from the nest.

I realize that the use of carbon bisulphid is very expensive, and this suggestion of yours interests me very much.

VICE-PRESIDENT E. R. SASSCER: We will proceed to the papers on the Japanese beetle and the first paper is "The Status of the Japanese Beetle in 1924," by L. B. Smith, which I am advised by Mr. Smith be read by title.

The next paper is by Messrs. J. L. King and H. C. Hallock.

## A REPORT ON CERTAIN PARASITES OF *POPILLIA JAPONICA* NEWM.[1]

By J. L. KING, *Associate Entomologist* and HAROLD C. HALLOCK, *Junior Entomologist*, *United States Department of Agriculture*[2]

ABSTRACT

The content of this paper is largely a summary of the parasite introductory work at the Japanese Beetle Laboratory, Riverton, N. J. This work was started in 1920 and is still being continued.

The important points discussed are the importation of an important Tachinid, *Centeter cinerea* Ald., in 1920 and its successful establishment in New Jersey in 1923 and the subsequent spread in 1924. The establishment of a second colony of this parasite in Pennsylvania during 1924 is also mentioned.

The failure of refrigeration shipping methods as used for *Ochromeigenia ormioides* Town., and the methods of rearing large shipments of a Dexiid parasite, *Prosena siberita* Fab., are also discussed. There are a few concluding remarks on the rearings of *Tiphia popilliavora* Roh.

The foreign work on the parasites of *Popillia japonica* was begun in the spring of 1920. Since that time investigations on this phase of the work have been continuous and a large number of parasite shipments have been made to the Japanese Beetle Laboratory at Riverton, New Jersey. As there are no complete published records of this period of introduction into the American field, it is deemed advisable to present a brief account of the work done with the various species which have been

[1]Contribution No. 6, United States Department of Agriculture, Japanese Beetle Laboratory, Riverton, New Jersey.

[2]The writers wish to acknowledge the careful supervision of the parasite work prior to 1924 by Mr. Loren B. Smith, now Director of the Japanese Beetle Laboratory.

received at this laboratory. A brief statement of the foreign phase of the parasite work together with short biological notes on the species mentioned here may be found in the following reference: Clausen, Curtis P., and King, J. L., Preliminary Report on the Foreign Parasites of *Popillia japonica*. In Jour. of Econ. Ent., vol. 17, pp. 76–79, 1924.

## Discussion of the Various Species

*Craspedonotus tibialis* Schaum. This predacious carabid beetle was first received at the Riverton laboratory during the summer of 1920. At that time a shipment of 1,100 beetles arrived. This was followed by two more shipments totaling 15,350 during 1921.

Approximately fifty per cent of the beetles arrived in good condition and, although they became established during the summer months, producing eggs and larvae, they apparently were unable to survive under the new conditions. No further attempts to introduce this species have been made.

*Centeter cinerea* Ald. The first consignment of this Tachinid parasite consisted of 700 puparia collected by Mr. C. P. Clausen in North Japan during the summer of 1920. This shipment was not forwarded to America until the following spring. During the summer of 1921 Mr. Clausen and the senior writer collected 118,000 parasitized beetles. This lot was also wintered in Japan and shipment was made early the following spring. The 1922 collections consisted of 144,000 puparia, which were shipped to Riverton during the fall of the same year. Similarly 50,000 puparia were collected and shipped during each of the summers of 1923 and 1924. In all cases the puparia were shipped within the bodies of the dead host beetles and these were packed in moist sphagnum, except the shipment of 1924 which was packed in moist sawdust.

The first shipment in 1921 resulted in twenty-four individuals, which were not liberated but were kept for life-history observations. The 1922 shipment produced 700 individuals. These flies were liberated in the summer of that year but no eggs were found on *Popillia* beetles during that season. However, owing to the large number of flies liberated it is quite probable that *Centeter* was established sparsely at that time. In June, 1923, futile attempts were made to recover this species as a matter for record prior to the release of a subsequent rearing of 6,400 *Centeter* released in the same locality. Beetles bearing fertile eggs of this parasite were observed shortly after liberation of the flies in this locality. The following year, 1924, a careful *Centeter* egg survey was

made and it was found that this Tachinid had become established and had spread in New Jersey over an area of about 12 square miles. A colony was also started during the summer of 1924 at Torresdale, Pennsylvania, by the release of 2,000 *Centeter* reared from the collections made in Japan during the summer of 1923. Shortly after the liberation of the Tachinids in this vicinity, fertile parasite eggs were observed on the beetles. As this tachinid is able to withstand our winters this colony doubtless will persist.

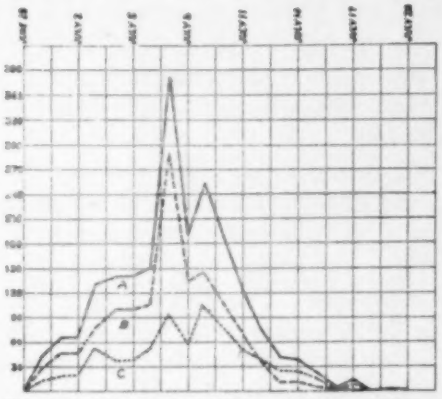

Fig. 20.—*Centeter cinerea* Ald. in 1924: *A*, total emergence; *B*, emergence from material wintered outdoors; *C*, emergence from material wintered in cool cellar.

The 50,000 puparia received in October, 1923, were wintered at the laboratory under varying conditions in order to determine the best method of handling hibernating material. Eighty-three per cent of the puparia were wintered in a cool cellar in which the temperature ranged from 35° to 45° F. The remaining 17 per cent of the puparia were placed under cages out of doors. The puparia were covered with an inch of soil, which, in turn, was covered with about two inches of dead leaves. This material, wintered under the varying conditions of nature, produced 66.6 per cent of the total *Centeter* flies, whereas the cool cellar material produced only 33.3 per cent of the total adults reared. Fig. 20 shows the daily variations between these two lots and the total emergence in 1924. It was observed in the cool cellar material that many of the pupae within the puparia had developed to the point of emergence when death occurred. The material wintered under more natural conditions gave rise to seemingly stronger and more active adults.

*Ochromeigenia ormioides* Town. During July, 1923, two shipments of *Popillia* beetles parasitized by a nocturnal tachinid, *Ochromeigenia ormioides*, were received from Japan. The cases containing this shipment were sent in cool storage from Yokohama and on arrival in Seattle they were packed in iced containers for transcontinental shipment. In spite of the care given this material, no adults were reared. Later examination of the dead beetles, however, showed the percentage of parasitism to have been 1.8 per cent in the first lot and 4.9 per cent in the

second lot. The shipping time of these consignments from Yokohama to Riverton, New Jersey, was 18 days.

In 1924 five shipments of *Ochromeigenia* were received. The first two shipments were divided so that part was packed in iced containers from Seattle to Riverton and part was expressed at car temperature. Experience with these shipments clearly demonstrated the constant failure of the iced material to survive the resulting low temperatures, while the un-iced material produced a number of perfect adults. As the problem of successful transportation is now solved, quantity shipments are all that remain necessary to give this species greater possibility of becoming established.

On receiving this material at the laboratory it was immediately unpacked and after the excess debris was removed the dead beetles containing the puparia were placed in large battery jars 9 inches by 15 inches. They were then covered with a two-inch layer of moist sterilized sawdust. The flies emerging under these conditions were normal. The total number reared during 1924 was 177 and almost all of these were liberated after being held in a large cage for twenty-four hours to facilitate mating.

*Eutrixopsis javana* Town. This tachinid was reared first at the Japanese Beetle Laboratory in June, 1923. It had attacked a number of beetles which bore *Centeter* eggs and was therefore unwittingly shipped to the laboratory at Riverton. Two hundred and ten individuals were reared and about 190 were liberated. This parasite has not yet been regained in the field. Owing to the low percentage of parasitism affected by this fly and its scarcity in Japan it is unlikely that attempts will be made to introduce the species.

*Prosena siberita* Fabr. A consignment of this dexiid parasite arrived at the Japanese Beetle Laboratory in April, 1922. This shipment consisted of 120 grubs which had been inoculated with first-stage *Prosena* larvae.[3] The second lot of inoculated *Popillia* grubs which consisted of 8,000 larvae reached the laboratory in October, 1922. The necessity of holding the inoculated grubs over a long period for development resulted in serious loss due to fungi and bacterial infection and the adults reared were entirely too few for use in the field.

In mid-July, 1923, a consignment of 12,380 Japanese beetle grubs was forwarded to the laboratory at Riverton. The parasitism of these grubs was approximately 10 per cent. These differed from the former in

[3]The method of inoculation of *Popillia* grubs with dexiid larvae will be described in detail in a forthcoming paper: The Parasites of *Popillia japonica* in Japan and Korea, by Clausen, C. P., King, J. L. and Teranishi, Cho.

that they were naturally parasitized by *Prosena*. Slightly more than 300 *Prosena* were reared from these grubs. After part of these flies had mated in captivity, 53 were released on a golf course near Moorestown, N. J., and 136 were placed in a large outdoor cage which had been stocked with *Popillia* larvae. No dexiids were recovered in the cage the following season and owing to the release of other rearings in 1924 it was impossible to check up on field conditions.

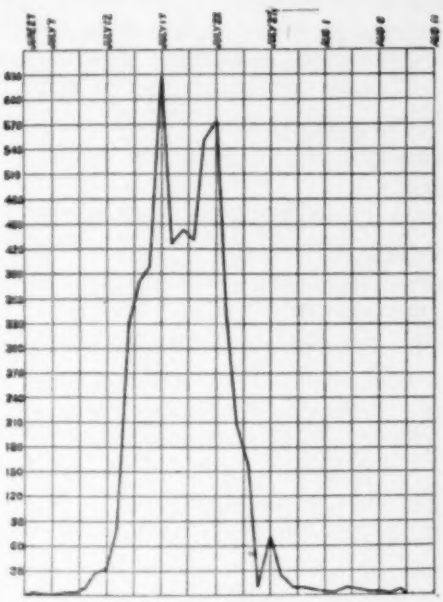

Fig. 21.—Emergence of *Prosena siberita* Fabr. in 1924.

The fourth shipment followed in June, 1924, when 49,000 Japanese beetle grubs arrived at the laboratory. Thirteen per cent of these contained larvae of the parasite. These grubs were packed in trays divided into 196 compartments allowing 2 cubic inches of soil for each larva. On unpacking this material the grubs were sorted from the Japanese soil and placed in a mixture of fresh sandy loam and sod. When the host larvae had been sorted the trays containing them were placed in a large rearing cage which was constructed with great care to prevent the escape of any secondary parasites. The inside dimensions of this cage were 22 feet long, by 7 feet wide, by 6 feet high; the sides and inner ceiling were covered with 16-mesh wire screening and lined with heavy muslin. The only entrance to this cage was through two small anterooms in which any secondary parasites could be detected and caught in case they attempted to escape when the cage was entered. As the dexiid parasites emerged from the trays, which had been piled in the center of the cage and separated from each other by blocks of wood, they were attracted by the light and flew to the muslin-screening on the sides of the cage where they were easily captured.

Emergence of this parasite ranges from June 27 to August 8, the maximum period occurring from July 14 to 25 as is shown in Fig. 21. The total emergence was over 5,000 flies; of these 4,975 were released

near Moorestown, N. J. These flies were released at the same locality as those of the previous year in order to strengthen any possible colony which may have started. This parasite is a strong flier and is very likely to become too sparsely distributed for its establishment unless large numbers are released. A few adults were observed at some distance from the point of releasement and in one instance a female was found in Palmyra, 4.5 miles from the center of liberation.

*Tiphia popilliavora* Roh. A shipment of 360 cocoons of this *Tiphia* was received at Riverton, N. J., in April, 1921. Only a very few individuals emerged from this shipment. These *Tiphia* were mated in captivity and after about 35 fertile eggs were obtained they were released.

The second shipment in April, 1922, consisted of 811 cocoons. This shipment netted an emergence of 235 adults during the summer. From this lot 43 mated and two unmated females were released near Riverton, N. J. A third shipment of 2,100 cocoons was received in December, 1922. From this lot 119 adults were reared but only 15 females were liberated, while the remaining were used in breeding experiments. None of the cocoons thus obtained produced adults.

The 43 mated females released in 1922 under favorable conditions made it quite possible for this species to have become established. However, it has not yet been retaken in the field.

*Tiphia vernalis* Roh. In August, 1924, a shipment of 5,300 cocoons of *Tiphia vernalis* Roh. was received from Korea.

*Tiphia* sp. A shipment consisting of 257 cocoons of *Tiphia* sp. was received in October, 1924, from Nanking, China. It is hoped that these will be reared successfully at the laboratory during the coming season.

*Campsomeris annulata* Fabr. This scoliid parasite was received at the Japanese Beetle Laboratory in December, 1923, when Mr. Clausen brought 4 cocoons of *Campsomeris annulata* from Suigen, Korea. No adults emerged from these cocoons. Again in August, 1924, 325 cocoons of *Campsomeris annulata* were received from Suigen, Korea; unfortunately this material was all dead on arrival, which was perhaps due to the excessive loss of moisture while in transit.

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VICE-PRESIDENT E. R. SASSCER: The next paper is by Mr. C. A. Thomas.

# OBSERVATIONS ON THE LIFE-HISTORY OF *POPILLIA JAPONICA* NEWM.[1]

By C. A. THOMAS, *Junior Entomologist, United States Department of Agriculture*

ABSTRACT

This paper compares the life-history of the Japanese Beetle (*Popillia japonica* Newm.) during the years 1922–23–24. It shows that the life history was similar in 1922 and 1923, but that in 1924 the spring and summer phases were delayed about 10 days, due probably to unusual weather conditions during that period. Various habits of the adult and larvae are also discussed.

This paper comprises field studies on the life-history of the Japanese Beetle (*Popillia japonica* Newm.) during the years 1922 to 1924 inclusive, in the vicinity of Riverton, N. J.

In the course of the observations the occurrence and abundance of the various stages of the insect were studied, and data were obtained on the rainfall, and soil and air temperatures. The data of these three seasons have been compared and the influences of these environmental factors have been correlated with the life-cycle of the Japanese beetle.

## METHODS OF OBTAINING DATA

The data on immature stages cover diggings in typical soils over a large portion of the territory infested by the beetle. These soils include all types from Sassafras gravelly sand, loamy sands and loams to peat. Sandy loams are most favored for egg-laying and the larvae develop best in that soil-type.

The data with respect to the emergence, abundance, and decline in the numbers of adults are based upon the decline in number of immature stages in the soil during the early summer, upon actual counts in particular plots throughout the summer, and upon comparative observations at scattered stations. Laboratory rearings are also taken into account.

## THE LIFE-CYCLE

The life-cycle may be divided into 3 periods or phases, which are: 1—the spring or late larval and pupal phase; 2—the summer or adult phase; and 3—the fall or egg and early larval phase.

### 1. THE SPRING OR LATE LARVAL AND PUPAL PHASE

This phase includes (1) the development of the larva after it regains its activity in the spring, (2) the prepupal stage, and (3) the pupal stage.

In early March the soil temperatures undergo a "turnover", i.e., the temperatures nearer the surface become higher than those at lower

[1]Contribution No. 7, Japanese Beetle Laboratory, Riverton, N. J.

levels, which is the reverse of the condition during the winter. This principle of temperature "turnover", as developed by McColloch and Hayes[2] in their studies of white grub activities, is also applicable to the movement of *Popillia japonica* larvae.

The majority of the larvae pass the winter in a dormant condition, at an average depth of 9 inches. When the soil temperature begins to increase in the spring, the larvae become active and a gradual upward movement takes place. By early May most of the larvae are within 4 inches of the surface, and in this upper stratum of the soil the development of the larvae is completed.

By late May most of the 3d instar larvae go into an inactive stage called the prepupa, and all the 3d instar larvae have changed into this stage by the last week in July. This prepupal stage lasts usually from 5 to 7 days, whereupon transformation to the pupal stage occurs.

Data gathered on the foregoing stages during the years 1922 to 1924 inclusive are shown in Table 1.

TABLE 1.—THE SPRING OR LATE LARVAL AND PUPAL PHASE

| | 1922 | 1923 | | | 1924 | | |
|---|---|---|---|---|---|---|---|
| | First Found | First Found | Height of Season | Last Found | First Found | Height of Season | Last Found |
| 3d Instar (ready for prepupa) | May 25 | May 25 | | July 7 | June 9 | | July 22 |
| Prepupa | May 29 | May 30 | | | June 11 | | |
| Pupa | June 3 | June 3 | June 20 | July 15 | June 14 | July 3 | Aug. 1 |

From these results it will be noted that the season of 1924 was much later for each stage of this spring phase than were the seasons of 1922 and 1923. The probable cause of this retardation is discussed further on in this paper.

### 2. THE SUMMER OR ADULT PHASE

The pupal stage is completed in from 9 to 12 days, whereupon the adult emerges from the pupal skin and remains in the soil cell for from 3 to 5 days until the chitin has hardened and the beetle has attained its normal coloration. Then the adult emerges from the soil and soon begins to feed on smart-weed and other low-growing plants. Male beetles are usually the first to emerge, the females not appearing until several days later. The first beetles emerge about June 11.

Within 5 to 7 days after emerging, fertile females return to the soil in the late afternoon, dig in about 2 inches and lay a few eggs. The

[2]McColloch, N. W., and Hayes, W. P.—"Soil Temperature and its influence on White Grub activities,"—Contribution 76, from Ent. Lab. Kansas State Agric. College.

next morning the female returns above ground and may not again enter the soil until several days later.

After feeding on low plants for a week to ten days the adults begin to feed upon the foliage of certain trees and within a few days a general movement into the trees occurs. In 1923 the first beetles on apple were observed on June 25 and a major movement of adults into the orchards occurred during the next week. In 1924, however, no beetles were found feeding in apple orchards until July 10th, with the main movement into the orchards in the week of July 13th. Each year, feeding in cherry, plum and peach orchards began about a week earlier than in the apple orchards. On corn, the first beetles were found feeding on July 5, 1923, but not until July 19 in 1924. The ratio of females to males on fruit trees is lowest early in the morning, when females comprise one-fifth to one-fourth of all the beetles on the trees. This ratio increases until about 2 p.m. when the females are about one-half of all beetles, then the number of females decreases again over night.

The beetles leave the fruit trees about the middle of August, after their numbers have begun to decline, and move to the lower plants.

The last beetles in 1922 and 1923 were observed on October 11th, and were males. In 1924, however, the last beetle, also a male, was not observed until October 23d.

### 3. The Fall or Egg and Early Larval Phase

The egg stage averages about 11 days in length, the exact length of this stage being determined to a large extent by the temperature and moisture of the soil in which the eggs are laid. They are laid loosely in the soil and do not have a pellet of soil around each one as do some scarabaeid eggs.

The larvae, upon hatching, are about 2 mm. long and begin to grow rapidly, feeding on surrounding grass roots and decayed organic matter in the soil.

The duration of the first instar is approximately 12 days. Most of the second instar larvae change to the third instar by mid-October, although a few live over winter as 2d instar larvae and change to the third in May of the next year. Thus during the winter only the larval stages are present, about 97 per cent of these being the third instar, the remainder second instar. The highest percentage of second stage larvae is found along the borders of streams and ponds where the soil is wet and cold and the development thereby retarded.

The larvae feed on grass roots until late November, when lowering temperatures and other factors cause them to move slowly downward

to a depth of from 8 to 12 inches where they spend the winter. The depth varies somewhat with the soil type. A curve of the movement follows very closely a curve of the mean soil temperature decrease in the fall. The data on the fall or egg and early larval stages are shown in Table 2.

TABLE 2.—THE FALL OR EGG AND EARLY LARVAL PHASE

| | 1922 | 1923 | | | 1924 | | |
|---|---|---|---|---|---|---|---|
| | First Found | First Found | Height of Season | Last Found | First Found | Height of Season | Last Found |
| Adult | June 11♂ | June 11 ♂ | July 14–20 | Oct. 11 | June 21♂ | July 25–30 | Oct. 23 |
| Eggs | June 18 | June 21 | July 12–15 | Aug. 15 | July 7 | July 22–25 | Sept. 1 |
| 1st Instar | | July 2 | Aug. 1 | Late Oct. | July 15 | Aug. 10–20 | Mid-Nov. |
| 2nd Instar | | July 15 | Aug. 20 | 1% over- | Aug. 2 | Sept. 1–10 | 3% over- |
| 3d Instar | | Aug. 1 | Late Aug. on | winter | Aug. 12 | Late Oct. on | winter |

It will be noted from the data given that *Popillia japonica* Newm. has a one-year life cycle in New Jersey. There is no evidence of a two-year cycle here as occurs in North Japan.

## INFLUENCE OF WEATHER CONDITIONS AS A POSSIBLE CAUSE OF RETARDATION

As shown in Tables 1. and 2., the development of the various stages was considerably retarded in the spring and early summer of 1924 as compared with the preceding two years. The exact cause of this subnormal rate of development is not definitely known, but the data at hand would seem to show that low temperatures were chiefly responsible.

The life history during 1922 was very similar to that in 1923. Also, there is a close similarity between the two years in the mean soil temperatures for the thirty days previous to the emergence of the adults. In 1924, however, data on the thirty days previous to adult emergence show the mean soil temperatures to be about 4 degrees Fahrenheit below the means of the same period in the previous two years. The thirty-day period previous to adult emergence is significant as most of the late larval, and all of the prepupal and pupal development occurs in this period.

Rainfall, and consequently, soil moisture, apparently did not have an important influence in the retardation in 1924, except, perhaps, as it may have influenced the soil temperatures. In 1923 the rainfall during the thirty day period was considerably below normal, while in 1922 and 1924 the rainfall was much above normal, and the amount of rain-

fall of these two years was about equal. The soil was much wetter in 1922 and 1924 than in 1923.

The data on mean soil temperatures, rainfall, and date of emergence in each year are given in Table 3. The soil temperatures at 3 inches were chosen because most of the spring and early summer development occurs at 2 to 3 inches below the soil surface.

TABLE 3.—COMPARATIVE DATA ON MEAN SOIL TEMPERATURE AND RAINFALL FOR THE 30-DAY PERIOD PREVIOUS TO ADULT EMERGENCE

| Year | Date of Emergence | Mean Soil Temperature (At the 3-inch depth) | Rainfall (inches) |
|---|---|---|---|
| 1922 | June 11 | 60.2 | 4.46 |
| 1923 | June 11 | 59.5 | 1.05 |
| 1924 | June 21 | 55.7 | 5.58 |

(These soil temperatures were taken in sandy loam soil, as this is the soil type from which the first beetles emerge each year.)

From these data it would seem that low soil temperature was the important factor in the retardation of the spring and early summer development during 1924, and that soil moisture apparently had no appreciable effect except as it may have influenced soil temperatures.

## SUMMARY

The Japanese beetle (*Popillia japonica* Newm.) has a life cycle of one-year in New Jersey. There is no evidence that it may have a two-year cycle here as it does in northern Japan.

In the spring the larva moves up through the soil to a point just under the surface, enters the prepupal stage prior to pupation, and the adult emerges about mid-June. Eggs are laid in the soil throughout the summer and the first larvae hatch in early July. All larvae have passed through the first instar stage by late Octobe., and only the third instar larvae and a few of the second instar go through the winter. They remain in a dormant state from 8 to 12 inches below the soil surface.

Data collected during the last three years show that the life-history during 1922 and 1923 were similar but that in 1924 the spring and summer stages were from 10 to 14 days later than in the preceding two years. The weather data for the same years show that the mean soil temperatures during the developmental period in 1922 and 1923 were also much alike, but were somewhat above the mean temperatures of the same period in 1924. The rainfall of this period in 1923 was considerably below normal, while in 1922 and 1924 it was much above normal.

Of the environmental factors causing variation in life-history during the years 1922, 1923 and 1924, the conclusion reached is that soil temperature was probably the most important factor, with rainfall, as affecting soil moisture and soil temperature, less important.

VICE-PRESIDENT E. R. SASSCER: The next paper is by B. R. Leach and W. E. Fleming.

## THE FUMIGATION OF "BALLED" NURSERY STOCK[1]

By B. R. LEACH, *Associate Entomologist*, and W. E. FLEMING, *Assistant Entomologist*, *United States Department of Agriculture*

ABSTRACT

In the past, balled nursery stock has not been successfully fumigated in a closed container because the aerial portion of the plant succumbed to the action of the gas. As a result of experimental work at the Japanese Beetle Laboratory, a closed container has been designed for this purpose. It consists of a tank filled to a certain level with water leaving an air space above for the gas. The plants are inverted and the aerial portions submerged in the water while the soil-balls are exposed to the action of the gas. Carbon disulphide has been found most satisfactory as a fumigant. The preliminary data have been obtained and would seem to indicate the advisability of continuing the experimental work with the object of adapting the method to large-scale treatments for this class of nursery stock.

Numerous attempts have been made to fumigate growing plants with soil about their roots for the purpose of destroying insects living in the soil. Whenever plants were placed in a fumigation chamber and subjected to the action of an insecticidal gas, the aerial portions were invariably injured. Carbon disulphide gas, for instance, is very efficacious in penetrating a soil-ball and killing any larvae of *Popillia japonica* Newm., present therein but this gas will usually injure the aerial portion of the plant.

Under the circumstances, it was believed that the only logical way in which stock of this class could be fumigated is by protecting in some way the aerial portion of the plant from the action of the gas, the soil-ball meantime being subjected to the gas. Further consideration of the problem suggested the possibility of coating the foliage of the plants with a colloidal material before subjecting them to the action of the gas, the coating to be removed from the foliage after the fumigation was completed. At this stage of the investigations the suggestion was made by Dr. P. A. van der Meulen[2] that the aerial portion of the plant might be protected by submergence in water during the period of fumigation, a method frequently employed in the chemical field for the protection of material from the action of gases. The question of a colloidal coating was therefore reserved for future study since a quick solution of the problem was imperative and the submergence method appeared to offer

[1]Contribution No. 2, United States Department of Agriculture, Japanese Beetle Laboratory, Riverton, New Jersey.

[2]Agent, United States Department of Agriculture.

an answer without a probable long period of preliminary investigation. Subsequent tests have proved the soundness of this suggestion made yb Dr. van der Meulen, although it was necessary to modify the suggestion in one important respect as will be shown later in the paper.

The initial experiments were made in a simple apparatus composed of a cylindrical galvanized-iron chamber 18 inches in diameter and 24 inches deep equipped with a tight-fitting cover, fan and thermometers and half filled with water.

In the first experiments, the plants were inverted so that their tops were submerged in water[3] and varying dosages of liquid carbon disulphide were injected through a stop-cock in the closed lid into an evaporating pan. At the end of a definite period of exposure to the gas the plants were removed from the container and kept under observation. Certain carbon disulphide concentrations killed the larvae embedded in the soil but the aerial portions of the plants, *although submerged during the fumigation period*, were injured owing to the absorption of the carbon disulphide gas by the water in which they were submerged. This absorbed carbon disulphide was readily detected in the water by chemical analysis and was of sufficient concentration to kill larvae suspended therein during the fumigation period.

As a result of these experiments, an attempt was made to prevent this absorption of the gas by coating the surface of the water with vegetable oils such as cottonseed and olive oils. It was not found possible to maintain an unbroken film with the quantities of those materials which it was practical to use. This failure of oils to function in this respect was due apparently to the tendency of the oil-film to break when in contact with carbon disulphide vapors. Furthermore, the oil had a tendency to injure the foliage of plants.

In view of the limitations of the oil-film, it seemed advisable to try to limit the absorption of the gas by the water by constantly removing the surface water containing the absorbed gas and replenishing the container at the bottom with fresh water. The apparatus described above was therefore adapted to this method. Experiments conducted with this improved apparatus showed that the submerged foliage was uninjured by the gas when the surface water was constantly removed and the water level maintained with fresh water added at the bottom of the tank.

This apparatus used for demonstrating the soundness of this procedure was not adapted to extensive experimental work with the balled plants.

[3]Preliminary experiments in the submerging of the tops of such tender planta as Salvia and Calendula in water for 48 hours resulted in no injury to the foliage.

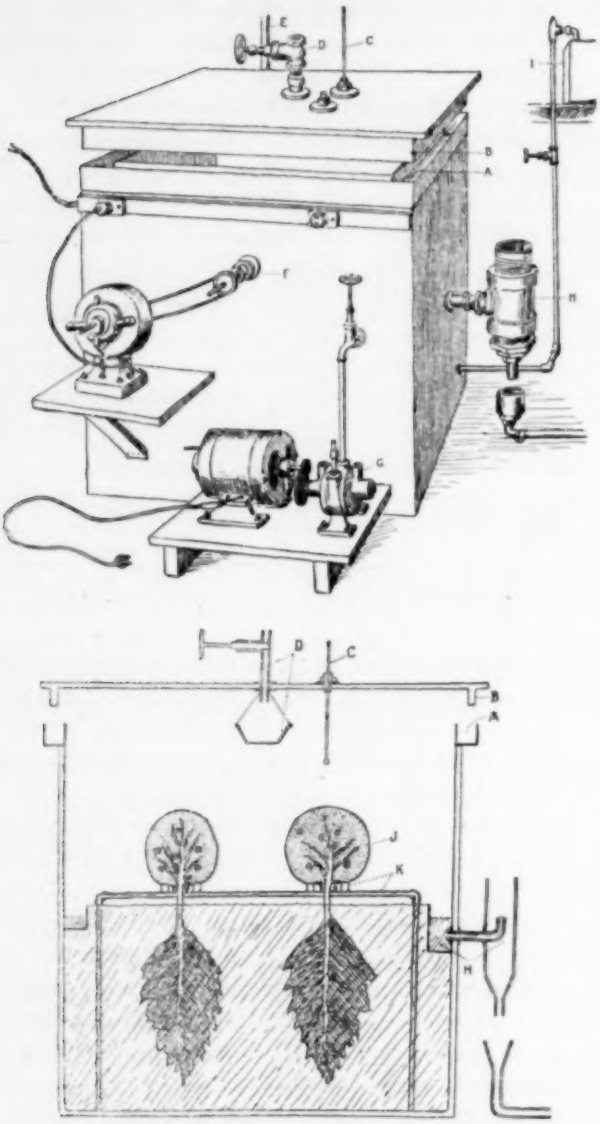


Fig. 22.—Experimental apparatus for the fumigation of balled nursery stock by submersion method. (*A*) Water trough with (*B*) cover fitting into it. (*C*) Thermometer (*D*) Gate valve and pan for application of carbon disulphide liquid, (*E*) Exhaust pipe for blower, (*F*) Stuffing box for electric fan shaft, (*G*) Blower (*H*) Constant level water overflow, (*I*) Overhead water supply tank, (*J*) Soil ball with aerial portion of plant submerged in water, (*K*) Supports for plants.

The apparatus shown in Fig. 22 was therefore developed and is capable of handling a balled plant 2 feet in height. The equipment consists essentially of a tank of water with a closed air space above it and the proper mechanism for controlling the water and the toxic gas.[4]

Utilizing this apparatus, fumigation tests were run for 10 months between February 1 and December 1, 1924, this period being comparable to the spring and fall shipping seasons of the nursery industry. As would be expected, there is one condition which must be avoided in the fumigation treatments, namely, *a wet soil*. The gas will not penetrate through mud. Bearing this point in mind, experiments have shown that there are three factors which must be considered in these treatments, the concentration of the gas, the period of fumigation and the temperature. Within certain limits, unfavorable conditions as regards some one factor can be compensated by more favorable conditions in the other factors. For instance, fumigation at relatively low temperatures can be carried on by increasing the concentration of the gas and lengthening the period of exposure. There is, however, a limit to the extent of the manipulation of these factors. In the preliminary tests, an arbitrary period of fumigation, namely, 18 hours, was selected and data were obtained on the other two limiting factors of dosage and temperature. It was found that a concentration of 0.1 cc. of liquid carbon disulphide to a liter of air space in the chamber was a killing dosage within the temperatures encountered. With these data in hand, tests were made for the purpose of determining the period of fumigation. It was found that, regardless of the dosage employed, a complete mortality could not be obtained under 8 hours. Some data as regards the effect of the temperature of the soil, water and air were obtained during the course of the experimental work but the limitations of the experimental apparatus precluded the obtaining of data at temperatures lower than 50°F. Early in the process of the experiments it was found, as would be expected, that *wet* soils could not be treated with any degree of satisfaction. Aside from this question of excess moisture no obstacle has as yet been encountered from the soil angle. The results indicate that heavy and light soils as well as all gradations between can be fumigated provided they are not wet. The results from the plant standpoint have been consistently favorable in that the plants in general apparently withstand higher concentrations of the gas and longer periods of fumigation than do the larvae of the Japanese beetle.

[4]The apparatus is 3 feet square and 3 feet deep, inside measurements. The water is 18 inches deep, leaving an air space above of the same volume.

Considering the results as a whole, there has been only one disappointment to date, the weakness of carbon disulphide as a fumigant for the egg stage of this insect. Relatively high concentrations of the gas have signally failed as a control for this stage of the insect and the compound must of necessity be fortified with another material more toxic to the eggs or be set aside entirely for another compound during the period of the year when eggs are present in the soil. Work is now under way at the laboratory on this phase of the problem.

In view of the generally favorable nature of the results obtained with this experimental unit, a larger apparatus constructed from the standpoint of large-scale treatments has been built during the past summer. The principles embodied are essentially the same as those of the smaller apparatus (Fig. 22). It consists of a concrete tank 9 feet deep and 10 feet square, the walls being 6 inches in thickness with a gutter of channelled steel embedded in the top. The water in this tank is maintained at a depth of 6 feet by means of overflow stand-pipes leading to a pump which forces the water under slight pressure up through an overflow spraying nozzel from which it drops back into the smaller tank fitted with a constant level float valve. The water during this procedure is aerated and loses the larger proportion of the carbon disulphide gas which it may have absorbed in the fumigation chamber. From the aeration tank, the water flows back to the bottom of the submerging tank. The doors are covered with metal sheeting and are supplied underneath with a lip which drops down into the channelled gutter filled with water, thus making an air-tight compartment. The doors are opened and shut by means of chain hoists. Carbon disulphide liquid is introduced into the chamber through a small gate valve in one of the doors and drops into a wide shallow pan located directly in the path of an air-draft produced by a fan. At the conclusion of the period of fumigation, the charge of gas is emptied by means of an electric blower.

This apparatus was not completed in time for the carrying out of any experimental work this fall but will be utilized in the spring for a series of large-scale tests.

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MR. HENRY FOX: I would like to ask Mr. Leach if experiments have been carried on to see if the grubs will develop in soil in which blueberries are grown.

MR. B. R. LEACH: We have no reason to suppose they won't because white grubs have always been a problem more or less in the White's Bog Blueberry Nurseries, and I believe the Japanese beetle grubs have been found there.

MR. HENRY FOX: But what about the reaction of the soil?

MR. B. R. LEACH: Mr. Smith just tells me that they have been run for a year in that particular type.

MR. HENRY FOX: That is all right, then.

MR. J. E. GRAF: Are there any temperature limits, below which this fumigation is not effective?

MR. B. R. LEACH: We have found that there are 3 factors in this particular operation, that is, temperature, length of period of exposure to the gas and dosage. We find that we can make up for low temperatures (certain degrees of low temperature) by juggling the other two factors; that is, we can increase the length of exposure and dosage up to a certain point. We are only now in a position, through the development of this outside apparatus, to find out what the limits are with respect to low temperatures. It is apparently satisfactory at 50° F.

MR. J. E. GRAF: Is humidity a factor as your temperatures decrease?

MR. B. R. LEACH: Humidity of atmosphere?

MR. J. E. GRAF: Yes.

MR. B. R. LEACH: Apparently not. The one limit on this treatment is soil moisture.

VICE-PRESIDENT E. R. SASSCER: The next paper is by E. R. VanLeeuwen and Dr. P. A. van der Meulen.

## COATED ARSENATE OF LEAD

By E. R. VAN LEEUWEN, *Assistant Entomologist*, and P. A. VAN DER MEULEN, *Agent, Bureau of Entomology, United States Department of Agriculture*

ABSTRACT

This paper deals with the coating of lead arsenate with a metallic soap and its use against the Japanese beetle (*Popillia japonica* Newm.). When lead oleate is precipitated under proper conditions it forms an intimate mixture consisting of globules of lead oleate with uncoated particles of arsenate of lead. After drying the lead oleat spreads upon the surface of the arsenate of lead powder and upon the leaf and produces a coated material which adheres very firmly to the leaf surface.

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VICE-PRESIDENT E. R. SASSCER: The next paper is by L. B. Smith and E. A. Richmond.

## GERANIOL, A PRIMARY ATTRACTENT OF THE JAPANESE BEETLE

By L. B. SMITH and E. A. RICHMOND

(Withdrawn for publication elsewhere)

MR. F. C. BISHOPP: I would like to ask if you observed any special relationship between the sexes as to attractiveness. You mentioned it in an indefinite way but I didn't quite gather whether there was a definite relationship.

MR. L. B. SMITH: We do not feel we can make very definite statements yet concerning attraction, except in the case of Geraniol; one-third more females were obtained in our collection than males. That may be due to one of several reasons. It may be that the females come from the ground and due to their hunger are more easily attracted than the males, which do not spend as much time in the soil. I am not in position to say whether we believe the larger collections of females is due to sex relationship, to chemotropism or to a food stimulus which may occur at that particular time.

VICE-PRESIDENT E. R. SASSCER: That concludes the program of papers.

President A. F. Burgess resumed the Chair at this point when the final business of the meeting was transacted.

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**The Use of Calcium Cyanide Dust Against *Vespula carolina* Linn.** After reading the note by George S. Langford in the October, 1924, issue of the JOURNAL OF ECONOMIC ENTOMOLOGY, on the use of calcium cyanide dust to kill *Vespa infernalis*, it occurred to me that our experience in using this dust for the control of another species would be of interest. About September 20 we located a nest of *Vespula carolina* Drury where it was desired to erect a shed. We knew that they could be gotten rid of only with great difficulty and perhaps danger by using hot water or some other crude method. Without experimenting with other remedies, therefore, we put a considerable quantity of calcium cyanide dust at the entrance of the nest. It is not known if any of the dust actually went in the burrow to the nest. All the insects returning from the field were killed practically instantly, and never really entered the nest. After one and one-half hours, we excavated the nest and it was found that every adult insect within had been killed by the gas, and there seemed to be literally thousands of them. The nest was about eight inches in diameter and ten inches high and contained also thousands of larvae and pupae. It was placed in the laboratory for a few days, and during this time quite a number of the younger stages developed to adults. Thinking it might be unpleasant to have them so near us, the nest was taken to the attic and placed near an open window. It was placed with the bottom side up, or the reverse of the position it occupied in the ground. After more than a month the adults are present in increasing numbers and are ready at the slightest provocation to defend their nest. As stated before, they have access to the open window and go in and out at all times of the day. The plan now is to see if these insects will continue to multiply in the nest after it is removed from the soil and also if the reversal of the position of the nest interfered with their existence.

W. W. YOTHERS, *U. S. Bureau of Entomology,*
*Orlando, Florida*

## Papers Presented Before the Section of Apiculture, December, 1923

### RESEARCH PROBLEMS ADAPTED TO GRADUATE STUDENTS

By F. B. Paddock, *Ames, Iowa*

Abstract

This paper given under the head of a symposium for teaching apiculture. It summarizes the opinions of different people in regard to the value of research and the requisites of one who is to devote himself to investigational work.

We are reminded by Secretary of State Hughes (1) that, "It is not the function of the Universities to develop a mere mental agility, a craving for intellectual surprises, a dominant desire in the language of the day to be able to *sell* something, to *put something over*. In the world of slight attention, of content with fleeting impression, of inaccuracies, when the daily food consists largely of rumors and conjectures so treated as to be indistinguishable from facts, where truth is almost always belated, is apt to appear after keen interest has been lost, it is far more necessary than ever that our institutions of learning, should recognize that their chief function is to maintain the standards of sober and correct judgment and a fine disdain for those who make motion a substitute for thought." Again E. G. Mahin in an address before the Section on Chemical Education of the American Educational Chemistry Association, says, "Any person who expects to devote merely left over energy and surplus thoughts to superficial aspects of any science is foreordained to a career of attainment that is mediocre or worse." It is evident from these quotations that there is among our leaders of educational thought today, a feeling that true science is being neglected.

No doubt the first thing for us to do then is to consider, in a sober light, what science is. Probably the best definition of science or research is that given by Flynn as follows: "Research is the earnest, purposeful, persistent, intelligently directed effort to gain a new knowledge of a selected subject. The spirit of research is devotion to truth and insistent longing for better understanding."

It is well at this time that we should fully appreciate the meaning of this definition. Earnestness defines a condition which today is found in our Universities associated with every activity with a possible exception of research. Buchanan (2) says, that science is a system of organized facts. When properly taught and properly studied the contact with science, should develop the scientific point of view in the student. Put-

ting it in another way, science is made up of organized facts, properly interpreted. Closely associated with the fact that science is earnest, is the fact that science is honest. The true scientist must have the virtues of accuracy and modesty. Again science is progressive. In our research we discover new facts and these often displace errors. This has lead to the statement that there is nothing new under the sun and is sometimes discouraging to prospective graduate students. The consoling thought must be that our knowledge today is so largely made up of errors that even the displacement of one of those errors is a worthy ambition of research work. Sometimes the discovery of new facts may limit the vision of one who has not the true scientific thought.

Referring again to the definition, we find that research must be purposeful. The true scientist must recognize the fact that his work is altruistic. Facts discovered by research are seldom of immediate value to the discoverer but are given for the uplift and development of the human race. Most of the research work has as its aim, the discovery of some fact that will be of practical value to our development. This should not be construed as excluding pure scientific research, the result of which may apparently have no practical application. Very often we have found that discoveries have been made ahead of the time when they could be applied to our advancement. Again research must be persistent. This condition the student will find to be largely one of environment and for that reason the student who is coming to do his graduate work should have the value of an atmosphere in which research is established and conducted in a persistent manner.

Next, research must be intelligently directed. This, from the title of the paper, is the real crux of the situation. Referring again to Mahin we find this statement, "If the teacher is of broad reasoning, energetic, inspiring and inspired, he may fire his students with boundless zeal for the things and deeds of science, he may grip their intellects and emotions while in the class room or laboratories, he may fill them with the highest kind of resolve for high endeavor. Superficial training and narrowness of viewpoint are the blight of our system of scientific education today." Secretary Hughes remarks, "In all our educational schemes it must never be forgotten that you can not by the study of books, obtain the equivalent of contact with men."

In *Science*, E. C. Bingham (3) says, "The question whether students should select subjects of research of their own choice or from a list of suggestions proposed by their chosen Professor, has been raised by numerous student generations." In his discussion, he seemingly defends the

point of view taken by one school of research directors. This group feels that the student is attracted to the research problems in a definite line of work. The contention is made that the student comes to familiarize himself with this line of work and to attain the methods and technique used by the teacher in the research of this given line. The contention is held that any institution, no matter how largely endowed, cannot find it possible to provide necessary equipment for all the lines of research that might be developed by the graduate students. Rather, it is held that a more or less narrow line of investigation will develop as much as is desired. He says further, "As a matter of fact, training in research in our Universities is really training in methods of research and practically never in the particular research which the student may care to follow later. He is learning research methods and the particular problem is of light moment to the student." The other side of this discussion appears by A. W. Forbes (4) in which he says, "The young student can not ordinarily see connection of the research problems but he thinks the quality is more in the subject selected. The Professor is mostly interested in the fields that have been extensively studied, he wants to carry research one step further in the well-trodden road. To go ahead with such subjects it is necessary first to learn the work of other leading men."

As applied to our own field of Apiculture, what stand are we to take in suggesting research problems for the graduate student. Is it better to attempt to get the student's desire for a research problem or to attempt to direct his energy along those lines of work where the need is felt for research work. If the later course is pursued, it goes back to the personality of the research director. The lines of activity which need to be investigated, are entirely his personal views and very often these personal views are found to be covering personal ambitions. In our Universities today, students are often urged to take up a research problem which may be a very small part of the problem that the teacher has as his own line of work and which for lack of time or other reasons, he can not do. The question confronts us, are we developing individuality, and initiative in the student when the problem for his graduate work is waiting for him upon his arrival at the University?

In the definition of Flynn, we are reminded that research is the effort to give new knowledge. It may be difficult sometimes to properly define new knowledge. Too often the effort of the graduate student is dissipated in the search of stored knowledge which may be placed at the use of an investigator later. To be justified, research in its final analysis must produce something new. This need not discourage the student for

even a minor development in technique may be new enough to justify the effort on the research problem. How then, are we to decide on the proper subject for research for the graduate student. Unfortunately in Apiculture today, this selection is controlled by circumstances. Whether this is to the detriment of the development of the industry remains to be seen for research work in Apiculture in America is in its merest infancy. It is to be regretted that more departments where research in some of our leading institutions where Apiculture is conducted are not in a position to outline a program of research subjects as suggested by Dr. Bingham. He says, "There is only one criterion for such a program, does it deal with fundamental problems or are the purposes of only ephemeral interest."


REFERENCES

1. HUGHES, CHARLES E. Honored Educational Aims Remain Unaltered. School Life, Nov. '23.
2. BUCHANAN, R. E. Human Aspects of Science. Iowa State College, July 21, '23.
3. BINGHAM, G. C. Selection of Subjects for Research. Science, LVIII, Aug. 10, '23.
4. FORBES, A. W. Selection of Subjects for Research. Science, LVIII, Dec. 14, '23.


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## ARE COMMERCIAL HONEY SHIPMENTS LARGELY RESPONSIBLE FOR THE DISSEMINATION OF AMERICAN FOULBROOD?

By S. B. FRACKER, *Madison, Wis.*


ABSTRACT

This paper includes information gained from different parts of the United States in regard to whether commercial honey shipments, are responsible for the dissemination of American Foulbrood.


An important factor to be considered in determining upon any policy of American foulbrood control is the means of dissemination. This problem has been studied a number of times in the laboratory and in experimental apiaries. The possible agents include every article, organism, or product with which the bees or their equipment come in contact. As in other infections, however, laboratory studies have eliminated many of these possibilities from the list of serious probable sources of trouble and only a few remain.

White has pointed out[1] the evidence against infection being commonly carried in the water supply, from the nectaries of flowers, or by drones or queens. The marked success of the shaking treatment shows

[1] U. S. D. A. Bul. 809, pp. 34–36, 1920.

that *Bacillus larvae* does not survive on the exterior of the bee. Experience even shows that infection results in a smaller per cent of cases from the use of hives and broodless extracting combs from infected colonies than might be expected, although the persistent reappearance of a small percentage of infected colonies in large apiaries can often be attributed to this cause after other sources are eliminated.

This leaves (a) infection of the food supply and (b) the transportation of bees and infected combs, mainly from the brood chamber, as the sole important means of dissemination. The object of this paper is a consideration of the evidence on the relative importance of these two sources of disease.

The writer has already commented on this question[2] but recent developments have increased the interest in the subject. The problem is one of vital significance in determining the relative efficiency of restricting the movement of bees as compared with limiting honey shipments. Many beekeepers feel that the vital point of attack in preventing continued spread of American foulbrood is the regulation of honey shipments, a method which would immediately entail an enormous expense and probably seriously interfere with the present trade in honey.

The reasoning in such cases is that closing a lesser method of foulbrood dissemination will be a waste of time as long as the most common source of disease remains untouched. It is clear that if honey passing from place to place in ordinary channels of trade is a prolific source of infection, American foulbrood is destined eventually to be a universally distributed and permanent factor of American beekeeping. Since insurmountable difficulties seem to prevent effective regulation of the transportation of honey, any possible retarding of the spread of bee disease must come through hindering the movement of bees and infected equipment and will be successful only to the extent that such movement is now responsible for the introduction of foulbrood into new localities as compared with the proportion of cases which are to be traced to honey shipments.

That colonies of bees to whose workers infected honey is available will readily contract the disease has been demonstrated and is common knowledge. It is also obvious that moving an infected apiary or an infected colony of bees either when the beekeeper moves or in the purchase of new colonies for the enlargement of the apiary will also introduce foulbrood into new localities. As a result of the study of American foulbrood distribution in Wisconsin the writer has become convinced

[2]Journal Ec. Ent., p. 140, 1922.

that the introduction of American foulbrood is due almost entirely to the latter cause, and that commercial honey shipments are a factor of minor consequence.

Popular belief in the responsibility of honey shipments is based on data on bee disease distribution secured by the U. S. Department of Agriculture and maps showing the correlation between congestion of population and the introduction of American foulbrood. It is assumed that centers of population consume the most honey from the greatest variety of sources and therefore give the greatest opportunity for the distribution of disease by means of city dumps, garbage, the throwing out of honey containers, leaky barrels and honey cans in storage warehouses, and similar causes. This is doubtless true, but one can also reason that this correlation may be due to the greater movement of the population (including the beekeepers) in the vicinity of large centers. No accurate data on either of these two possible explanations is available, although I am informed by Professor Hibbard of the Department of Agricultural Economics of the University of Wisconsin that there is no question about the greater movement of urban population as compared to rural. We must therefore go farther than the locating of infection centers on a map and determine, if possible, as a matter of fact how the individual apiaries became diseased.

It has been shown in several published papers that American foulbrood was originally introduced into the state of Wisconsin with the importation of bees from Italy in 1870; that the spread of disease followed the death of the owner and the scattering of his apiary holdings. From this one apiary infected bees were introduced into Dane county near Madison, Grant county near Muscoda, and Calumet, Washington, Dodge, and Fond du Lac counties in the early nineties directly by the movement of beekeepers and the sale of bees and used bee supplies. So far as the names and dates have been obtainable these have been published.[3]

The record leaves no doubt but what in practice the movement of apiaries is responsible at least in part for the transportation of disease.

About the same time it was shown[4] that in a particular limited infected area "out of twenty cases of American foulbrood fifteen are apparently definitely known to have been transmitted by the movement of hives and comb, while of the other five little information is available."

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[3]Ball and Fracker: History of American foulbrood in Wisconsin, Biennial Report, Wisconsin D. A. 1917–18, pp. 71–6.

[4]Ball: Important Factors in the Spread and Control of American foulbrood. Journal Ec. Ent. 1918, pp. 200–5.

This investigation was made to determine the danger of infection from bee trees and local robbing, but it is equally interesting here. The only possible conclusion from these studies, which have been confirmed wherever introductions of American foulbrood are recent enough to be determined, is that the movement of bees and bee supplies is at least *an* important method of American foulbrood dissemination.

With reference to the effect of large centers of population, the Wisconsin records are also significant. Nearly twenty per cent of the population of Wisconsin lives in the city of Milwaukee, and the county also includes a number of populous suburbs. As a center of congested population it is ideal for such a study. Many carloads of honey from different parts of the United States are imported, as there are several bottling plants.

It is undoubtedly true that there has been a heavy American foulbrood infection in Milwaukee county, but a study of just where the infected apiaries are located reveals some surprising facts. As a result of an intensive apiary inspection campaign begun in 1919 and carried on every year since, it is believed that 99% of the apiaries in the county have been located. The number of beekeepers served by the central Milwaukee postoffice is forty-eight. This is the group located in the congested center of population where the greatest amount of honey is presumably consumed, and yet although honey from all sources, including infected ones, has undoubtedly been shipped into this section every year for at least half a century, only 7 apiaries (14%) have been discovered with disease, and the only one of these which has secured its first infection since the campaign opened was within a city block of a yard which had been infected for a long time. These seven may all have moved infected bees from elsewhere, but they at least include and probably exceed the total damage from the importation of honey into the main part of the city of Milwaukee since the introduction of the American foulbrood into the United States.

Immediately adjacent to the city to the southwest is a rural district which may conveniently be designated by its postoffice facilities which are through "Station D." This is the greenhouse district in which there is no congestion of population but there is an extensive movement of bees. In addition to the commercial beekeepers there are greenhouse proprietors each of whom maintains a single colony during part of the season for purposes of pollination. On our list from Station D there are now 73 beekeepers, 18 of whose yards (24%) have been found infected with American foulbrood during the past four years. In this location

while it is in the neighborhood of a congested population center there appears no reasonable cause for ascribing infection to the importation of honey, and it is a striking fact that the infecton is much more severe than where the population is most dense. Oakwood and Hales Corners are other rural neighborhoods in the same county and in them twenty-two per cent and thirty-three per cent respectively of the apiaries were found infected on the first examination.

From these records we are forced to conclude that the amount of honey consumed by the public from year to year within bee flight of the apiary (as determined by the population of the district) is not correlated with the amount of foulbrood infection.

Outside of Milwaukee, Wisconsin contains fifteen cities having a population of over 15,000 each. Complete surveys have been made of five of these and we are fairly familiar with the conditions in four or five others. Taking these in alphabetical order, Appletion was surveyed as a part of the clean-up campaign in Outagamie county. Its population numbers 19,561. There are 64 beekeepers receiving their mail from this postoffice mostly in or close to the city. Within an easy drive of the city (40 miles) are several American foulbrood infection centers and infected honey has doubtless been sold in Appleton from time to time or probably continuously for over twenty years. Of the 64 beekeepers only two were found to have American foulbrood and one of these was six miles from the city. The other is a large heavily infected apiary which may or may not have been moved from outside of the city limits. It is a striking fact that the other bees in the neighborhood have neither contracted the disease from robbing this one infected yard nor from the infected honey sold within bee flight of the apiaries.

In connection with the area clean-up campaign in Fond du Lac county over 150 apiaries were inspected whose beekeepers received their mail from Fond du Lac postoffice. This area was heavily infected, but as was stated above bees were moved into this district directly from the infected apiary in Jefferson county over twenty-five years ago, so at least the original source of this city infection is known.

Madison is in the same position as Fond du Lac, except that the infected bees were moved there in 1882 and American foulbrood has been present in the city ever since.

Oshkosh, a place of 33,112, was inspected in connection with the area clean-up campaign in Winnebago county. Although the city contains 52% of the county's population and contains 18% of the beekeepers, only three apiaries out of the twenty-five found infected in the county

were within the city limits and one of these was discovered to have the disease almost immediately after its arrival from another state. The chances are at least even, that it was infected before arrival.

Sheboygan, a city of 30,955, in a location where infected honey has probably been on sale for twenty to twenty-five years, never had a case of American foulbrood until a large infected apiary from outside the state was moved in in 1920. The county itself has only a light infection not exceeding seventeen diseased apiaries, but it is between two heavily infected counties and the source of honey containing American foulbrood has therefore been right at hand for a great many years.

An interesting point in this connection would be to discover what large cities there may be in the state in which no bee disease has been found. This condition is believed to be true of Superior and Eau Claire because of the existence of observant beekeepers in that neighborhood who have never seen a case. A partial survey of LaCrosse also fails to indicate any trace of disease within the city.

While the city of Richland Center is not so large, having a population of only 3,409, the intensive survey in Richland county is also interesting in this connection. The entire south tier of townships received an American foulbrood infection from the introduction of a diseased yard from Madison many years ago and the sale of the equipment in the yard, after the bees were dead, to the beekeepers in the neighborhood. The northwest part of the county is the apparent victim of the spread of American foulbrood from Vernon county, and an infection in the extreme northeast corner connects up with a general infection of Sauk county. Surrounded as it is and has been for years with infected districts containing many beekeepers, the infection running back a quarter of a century, American foulbrood has never been found either in the city of Richland Center itself or within four miles. This, in spite of the fact that infected honey must have been repeatedly sold there.

Another location with an interesting bee disease history is Antigo, a small city of 8,450. Langlade county, of which it is the county seat, seems to have remained free of disease until about 1915 when a beekeeper purchased several dozen hive bodies containing brood comb, from Wood county, an old infection center. American foulbrood soon showed up and spread to other yards. An energetic campaign had it practically cleaned up in 1919 when a new large yard from another state moved in and brought a new supply of infected material. Again active attempts were made to eradicate the disease, but in the spring of 1922 a shipment of nuclei from the south had the same effect. The first of

these interstate introductions resulted in an agreement by the inspectors of the northern states on a policy which has shut off this source of trouble; and the more recent one has placed the shipper in serious legal difficulties in his home state.

In connection with another phase of the subject the writer has shown that in an American foulbrood clean-up area unexplainable infections are not continually popping up in formerly clean yards either in cities or elsewhere. It was demonstrated in Jefferson county, for example, that while 95% of the honey on the open market is for sale in cities and villages of 1000 and over in population, less than one-half of the rare new infections after the campaign began were within such cities and villages.

So far as the evidence in Wisconsin is concerned we therefore feel justified in the conclusion that the only important means of dissemination of American foulbrood consists of the movement of bees and used bee supplies. All of the numerous cases of infection, the history of whose introduction is definitely known, fall within this class with the exception of only two individual cases where infected honey was responsible.

Thinking that Wisconsin's record on this matter might be due to the fact, that in our cold climate, honey distribution largely occurs after the beeflight period, inquiries on the question were sent to several southern states. There was insufficient time to go into the subject fully but the replies are of interest.

In Florida, as shown by published reports, infection is comparatively rare and sporadic. Mr. J. C. Goodwin writes "It is apparent to me that honey, equipment, apiarist, etc., are all to blame for the spread of the organism. Most of our spread is due to equipment being moved from one yard to another." He gives illustrations of the latter near Sanford and St. Petersburg, and cites a single case at Daytona in which honey was the apparent source, no other means of contamination being apparent.

In Mississippi, some inspection has been carried on in every county, and American foulbrood seems to be confined to the west-central and northwestern counties. It appears to have been introduced near Greenville from the northern states in a shipment of bees and equipment some years ago and is not connected with any population center. Prof. R. W. Harned writes, "We do not have any evidence to indicate that A F B is more serious near large cities and other centers of honey shipment." J. L. E. Lauderdale, Apiary Inspector of Mississippi,

states, "There is no doubt that *all* our trouble has come from used bee supplies and the movement of diseased bees."

Alabama apiary inspection has been limited in scope, but Mr. J. M. Robinson, who has been in charge, states in conversation that American foulbrood dissemination, so far as known, is correlated with active commercial bee keeping and the moving of bees and equipment, rather than with honey shipments.

Dr. M. C. Tanquary, former State Entomologist of Texas, says that honey shipments are greatly feared and cites one or two cases in which they were apparently responsible for the introduction of American foulbrood into clean territory. There are, however, many more cases in which infected bees have been introduced into new localities there and have caused the spread of disease.

In conclusion the writer does not desire to cast doubt on the *possibility* of infections arising from accidental exposure of infected honey, nor upon the prevalence of American foulbrood around Chicago, and New York, and other population centers. The evidence however appears convincing that the former cannot be considered the "chief" means of dissemination of American foulbrood, and it appears that the effect of population congestion on infection may possibly have been misinterpreted. As compared with the large numbers of known cases of bee disease distribution from the movement of bees and used bee supplies, the apiary inspectors of Wisconsin and of four southern states at least, find that honey shipments have been responsible for the trouble in only very rare cases.

The evidence may be summarized as follows:

1. In Wisconsin the introduction of this disease into the state and into many individual localities is definitely known to have been in specific importations of bees and equipment.

2. Cases of infection in which the source appears to be infected honey in the channels of trade are comparatively rare.

3. Even near such a large center as Milwaukee the infection percentage is greatest in localities of active movement, such as greenhouse areas, and is relatively low within the city itself.

4. Towns and cities of from 3,000 to 40,000 which have been natural markets for infected honey from nearby counties, have remained for years free from disease either until the present or until infected bees and equipment were introduced.

5. No new centers of infection are known to have been started since

the policy of limiting movement of bees and equipment was begun in 1919.

6. These observations appear to be confirmed by conditions in the south, in spite of the fact that the period of active flight of the bee tends to continue through the peak of honey distribution.

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## THE MOULTS OF THE HONEYBEE

By L. M. BERTHOLF, *Western Maryland College*

ABSTRACT

This paper gives observations made on larvae and pupae of the honeybee during the summer of 1923 at the Bee Culture Laboratory, Bureau of Entomology, U. S. Department of Agriculture. The moults for workers, queens and drones are given with detailed measurements for the different moults and description of color of the changing forms.

During the summer of 1923 at the Bee Culture Laboratory, Bureau of Entomology, U. S. Department of Agriculture, some observations were made on larvae and pupae of the honeybee which seemed to add materially to our knowledge of the developmental history of this insect. After the work was completed there was received a paper by Dr. Adrienne Koehler[1] in which were recorded many of the same observations. Having made some additional observations, however, as well as some which conflict with those of Doctor Koehler, it seems advisable to sum up all of these in the present paper, presenting in a general way the stages in the development of workers, queens and drones.

### WORKERS

THE EGG: During the three days of embryology the egg changes, as described in detail by Nelson,[2] from a single cell to a young larva. At the end of about 72 hours the egg can be seen to become transparent, first at the posterior, attached end, then gradually toward the free end, the change occupying some 10 to 20 minutes. It is readily noted that upon taking a frame of 3-day eggs from the hive few if any that are transparent are without larval food. This led Robbins in 1887[3] to experiment regarding the ability of eggs to hatch without larval food. He found that food was necessary for hatching and concluded that an acid in the food first put into the cell dissolves the chorion and frees the larva. Nelson

[1]Koehler, A., 1923. Ueber die postembryonale Entwicklung der Honigbiene. Landwirtschaftlichen Jahrbuch der Schweiz.

[2]Nelson, J. A., 1915. The embryology of the honeybee. Princeton University Press. 282 pp.

[3]Robbins, R. B. 1887. Making eggs hatch when taken from the bees. Gleanings in Bee Culture, XV, pp. 42–43.

and Sturtevant (1924)[4] however observed newly hatched larvae which were not provided with food, so that "the presence of larval jelly is not necessary for the escape of the larva from the egg shell." The following additional observations have been made concerning this point: Simultaneous with clearing, the spiracles are seen to open and close, first at the attached end of the egg and gradually spreading toward the free end as clearing advances. When clear the egg has the appearance of a hatched larva but when magnified the chorion with its polygonal areas c be distinguished still covering the larva. This condition remains indefinitely or until a drop of water or larval food is added, in which case the chorion floats up immediately on the liquid and the larva is freed. Several times eggs were found which seemed to have hatched, in cells in which there was no food, but in every case on sufficient magnification the chorion was found still to be covering the egg. This indicates that a larva in the hive cannot be said to be hatched until the bees put into the cell the first larval food.

THE LARVA: The head of the newly hatched larva measures 0.33 mm. in height (all head measurements were taken parallel with the first segment as the larva lies on its side and represents the extreme height of the head). Older larvae were examined and each was found to have a head measurement of one of the following numbers: 0.5 mm., 0.72 mm., 1.1 mm., or 1.6 mm. Since each of these is approximately 1.5 times the preceding number, it seemed clear, according to Dyar,[5] that these numbers correspond to the various stages in the development of the larva and that a moult might be expected for every change in head size. Accordingly, larvae of known age were obtained by permitting a queen to lay in a comb for a few hours and then removing her beyond a queen-excluder. The larvae then, as soon as they were hatched, were examined every few hours and moults were found to occur as follows: the first at 12 to 18 hours after hatching, the second at about 1½ days after hatching, the third at about 2½ days from hatching, and the fourth at 3¼ to 3½ days from the time of hatching. These numbers represent the result of observations on a number of frames of larvae of known age.

Just before a moult is to occur the larva seems to lose its shiny appearance and become rather dull and the old skin becomes visibly loosened at the anterior end. Then the skin splits over the head and, as the larva wriggles slightly, starts to move toward the posterior end. As it does so

[4]Nelson, Jas. A., Sturtevant, A. P., and Lineburg, Bruce. 1924. Growth and feeding of honeybee larvae. U. S. Department of Agriculture, Dept. Bul. 1222.
[5]Dyar, H. G. 1890. The number of moults of Lepidopterous larvae. Psyche V, pp. 420–422.

the lining of the foregut, of the hindgut, and of all the tracheae begin to pull out and move back with the moulted skin. All this can easily be seen if the larva is floated out on water in a watch glass and observed under low magnification. The moulted skin, as it is pushed off, collapses and floats out flat on the water behind the larva. In the cell the skins float out on the food and are later covered up by subsequent additions of food. Moulting occupies ordinarily less than 30 minutes.

At the end of the fourth day of larval life, then, the larva has moulted four times but is still comparatively small, weighing only six-tenths as much as a full-grown larva. The fact that the developing larva gains nearly four-tenths of its weight on the eighth and ninth days after egg-laying suggests the term gorging stage for these two days.

After the cell is sealed (at the end of the eighth day) and the cocoon has been spun (end of ninth day) the larva passes gradually and without moulting into a different stage which has been called the pre-pupa. Whereas up to the ninth day the larva has been active and lying generally on its side and curved to fit the shape of the cell, on the tenth day it stretches out on its back, head toward the mouth of the cell and becomes quiescent inside the cocoon. The skin gradually loses its shiny appearance and on the eleventh day clear, liquid-filled areas can be seen around the head, and the legs and parts of the head of the pupa can be distinguished underneath the old larval skin.

THE PUPA: Eleven days after the egg was laid the larva becomes slightly active for a few hours and moults for the fifth time, and there emerges the young pupa, motionless, and uniformly white in color. The old larval skin is pushed back to the base of the cell where it mixes with the yellow feces, given off by the larva during or just after the spinning of the cocoon, and the whole sticks to the base of the cell as a yellow flake. Sometimes young pupae are found which have only partly moulted so that the head is free but the old skin covers the rest of the body. Under this condition the insect has a half-larva half-pupa appearance and has apparently been mistaken by some as a semi-pupa stage. If the half-moulted skin is grasped with fine forceps, however, it can be pulled off and the ordinary pupa mentioned above is revealed. The young pupa is completely encased in a thin outer skin which is finally moulted at the end of the pupal stage, allowing the wings to expand and revealing the hair which covers the body.

Young pupae may be taken from their cells and placed in an incubator in a moist chamber and their development observed more closely. On the thirteenth day color begins to appear in the eyes, pink at first, then

gradually darkening until on the sixteenth day it is decidedly purple and when the adult emerges it has changed to brown. On the fifteenth day a slight greenish line appears in the abdomen due to the accumulation of a liquid feces in the intestine. A light brown color appears in the joints of the legs on the sixteenth day, gradually spreading over the whole thorax. On the eighteenth day the tips of the wings take on a dark color and the chitin on the abdomen becomes slightly tinged. A few hours before the sixth or final moult the antennae become colored, tips darkened at first, then the whole antennae so that the fully developed pupa is for the most part light brown in color except for the dark purple eyes and black antennae. Repeated observations on pupae kept in the incubator have failed to reveal any moults between that on the eleventh day and the final moult occurring generally on the twentieth day.

TABLE SHOWING MOULTS OF THE HONEYBEE

| Day | Workers | | Queens | | Drones | |
|---|---|---|---|---|---|---|
| | Stages | Moults | Stages | Moults | Stages | Moults |
| 1 | Egg | | Egg | | Egg | |
| 2 | | | | | | |
| 3 | | (hatching) | | (hatching) | | (hatching) |
| 4 | 1st larval | 1st moult | 1st larval | 1st moult | 1st larval | 1st moult |
| 5 | 2nd larval | 2nd moult | 2nd larval | 2nd moult | 2nd larval | 2nd moult |
| 6 | 3rd larval | 3rd moult | 3rd larval | 3rd moult | 3rd larval | 3rd moult |
| 7 | 4th larval | 4th moult | 4th larval | 4th moult (sealing) | 4th larval | 4th moult |
| 8 | Gorging | (sealing) | Gorging | | Gorging | (sealing) |
| 9 | | | | | | |
| 10 | Pre-pupa | | Pre-pupa | 5th moult | | |
| 11 | | 5th moult | | | Pre-pupa | |
| 12 | Pupa | | Pupa | | | |
| 13 | | | | | | |
| 14 | | | | | | 5th moult |
| 15 | | | | 6th moult (emerging) | | |
| 16 | | | Imago | | Pupa | |
| 17 | | | | | | |
| 18 | | | | | | |
| 19 | | | | | | |
| 20 | | | | | | |
| 21 | Imago | 6th moult (emerging) | | | | |
| 22 | | | | | | |
| 23 | | | | | Imago | 6th moult |
| 24 | | | | | | (emerging) |

THE IMAGO: About twenty days from the time the egg was laid the skin, which has been covering the pupa, is shed and the legs, wings, and mouth parts are freed. If it is in the cell the new imago begins immediately to chew its way out, emerging ordinarily on the twentieth or twenty-first day.

### QUEENS

Since fertilized eggs may become either queens or workers the embryology of both castes is of course identical. The first four moults occur at approximately the same intervals as in workers. During the gorging period however the increase in size is about twice as great as in the worker larva. The pre-pupa stage is short, probably less than one day, if we may so judge from the fact that the weight keeps increasing up to the tenth day and the fact that the final larval moult occurs at the end of the tenth day. The pupa stage lasts five days as against nine in the worker, the sixth or final moult occurring on the fifteenth day with emergence on the sixteenth day.

### DRONES

Embryology in the drones as in the other castes lasts three days. The first four moults occur at about 24-hour intervals after hatching. There follows then a gorging period of three days with an enormous weight increase to nearly three times that of workers. The pre-pupa stage lasts four days, the last larval moult taking place fourteen days after egg-laying. The pupa stage occupies eight to nine days after which a final moult frees the active imago on the twenty-fourth day.

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## THE NEW METHOD OF STERLIZING COMBS AFFECTED WITH AMERICAN FOULBROOD SO THAT THEY MAY BE USED AGAIN WITH PERFECT SAFETY

By E. R. ROOT, *Medina, Ohio*

ABSTRACT

This paper gives in brief the steps leading to the use of the Hutzelman solution for the control of American foulbrood. The mode of treatment, cost of treatment and cost of apparatus being included in the paper.

Dr. J. C. Hutzelman, of Glendale, Ohio, is the discoverer of a process for sterilizing combs affected by American foulbrood so that those combs for three or four cents each can be safely given back to the bees. As the invention or discovery has now passed the experimental stage I believe its importance to the beekeeping industry is surpassed only by the invention of the movable frame, the honey-extractor, the bee-smoker,

and comb foundation. Indeed, it may be doubted if it is not on an even par with them. It will enable the beekeepers of the country to save their valuable combs and at the same time enable them to hold the most serious pest that the beekeeper has to contend with—namely, American foulbrood—under control. I am convinced that, under the old method of treating, cutting out the combs, melting them up, etc., the disease has been spread, even by intelligent beekeepers, and under the very eyes of foulbrood inspectors themselves. The very act of cutting out the combs, cutting into the honey, and then storing them to be melted up later, involves the smearing up of tools, clothing, and other things, in a way that leaves remnants of honey everywhere, to which the bees may later gain access. Unless the containers holding the cut combs are leak-proof infected honey will ooze out, get under the feet, and then be tracked into the apiary. By the new method all that is necessary is to dip the diseased combs, if they contain no honey, into the sterilizing solution for 48 hours, at the end of which time they can be given back to the bees after airing and drying.

This new sterilizing solution contains formalin. The alcohol dissolves the scale, as it is a penetrant—that is to say, it will penetrate all *sealed* as well as unsealed cells of brood, whether diseased or sound. It will dissolve the scale, and even dissolve the wax if the combs are left in too long. The fact that the alcohol is such an active penetrant makes it possible for the germ-destroyer, formalin, probably the best known in the world, to kill the spores as well as the active germs of American foulbrood.

This solution has been tested in such a large way that it is now past the experimental stage. Thousands of diseased combs have been treated by this solution; and, so far as I know, not a single case of American foulbrood has reappeared in these combs when given back to the bees.

## The Mode of Treatment

All combs containing diseased brood, if they contain no honey, can be dipped immediately into the solution. At the end of 48 hours they can be used again after airing. All sealed honey when present in diseased combs should be uncapped. It is advisable to extract this honey or to soak the combs containing it in water for 24 hours. At the end of that time the water should be shaken out, or, better, extracted, when the combs will be ready for treatment.

After treatment the solution should be shaken out, or, better, extracted, and saved, because it can be used over and over again. Unlike

some germicides it does not lose its strength nor its power to destroy the germs.

Some extensive experience on our part, as well as that of others, shows that, at the present prices of the solution, the cost of the germicide per comb is less than 2 cents; or the total cost, including the labor, about 3½ cents. The cost of treating combs in a small way will, of course, be greater. The small beekeeper or backlot beekeeper, however, can treat his combs at odd hours at practically no expense for labor.

## Cost of the Old Treatment

The old treatment involved cutting the diseased combs out of the frames, boiling the old frames or buying new ones, melting up the wax, and having it made back again into foundation. This involves an expense, depending upon conditions, of anywhere from 18 to 25 cents per comb. On top of all this a frame of foundation falls far short of old black comb in the midst of a honey-flow, as every good beekeeper knows; and it therefore can be seen that the new treatment will not only save an enormous expense to the beekeepers of the country and of the world, but it brings a new era into the industry by putting it on a surer and safer foundation. The two hazards of beekeeping have been wintering and foul brood. The first has been almost solved, while the second has reached a stage where a beekeeper can clean up his own territory and bees at comparatively little expense.

## Cost of Apparatus

It is advisable to have a pair of rubber gloves, but these are not essential. One can use a pair of pliers with wide-opening jaws. The ordinary pliers used by automobilists will enable one to pick up the combs without getting his fingers into the solution. In the way of tanks, the ordinary 60-pound cans with the top cut off answer very nicely. About 7 combs can be put into a square can at a time. When the combs are in place the solution can be poured in so that over half of all the combs will be submerged. At the end of 48 hours the combs are turned end for end, and soaked 48 hours more.

If one desires to immerse the combs completely, all that is necessary is to lengthen out a square can. The material in any other square can will make it possible for an ordinary tinsmith to lengthen out two other square cans to more than comb length. In other words, two cans may be made out of three ordinary 60-pound square cans. In these two cans, seven combs to the can can be completely submerged.

If one wishes to do the work in a wholesale way, all that is necessary to do is to increase the number of his square cans. These can usually be had for a few cents. As a rule, the ordinary beekeeper in this country has a big supply of them that have but little or no market value.

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## THE HONEY BEE AS AN AGENT IN THE POLLINATION OF PEARS, APPLES AND CRANBERRIES[1]

By RAY HUTSON, *New Brunswick, N. J.*

ABSTRACT

The honey bee is a large factor in the pollination of pears and apples and is not of as great benefit in the pollination of cranberries, in New Jersey. These conditions are chiefly a result of weather conditions as related to the habits of honey bees and the like history of other pollinating insects.

Filippo Arena in 1763 noticed and wrote upon the phenomenon of insect pollination. During the years since Arena's time many men have studied the same problem. Hendrickson, Lewis, Morris, Vincent, and Waite[2] are some of the investigators who in recent years have enriched our knowledge of the agents of fruit pollination. In every case the honey bee has been listed as concerned in the transportation of pollen.

Eastern growers in general, however, have been slow to utilize the knowledge gained by these men; apparently because there are still points which need clearing.

Last spring and summer the New Jersey Station made an effort to answer some of these questions. The matters selected for investigation were: the amount of pollination due to honey bees; the number of other insects present; and the best method of placing the hives.

The possible amount of pollination due to honey bees was determined by enclosing pear and apple trees and cranberry plants in 12 mesh wire netting cages. Two adjacent similarly cultured Kieffer pear trees partially topworked to LeConte were inclosed in separate cages with ground inside covered with cheesecloth. As there were no apples partially topworked, two trees, a Jonathan and a Wealthy, were inclosed in each cage for the experiment on apple. The cages used for apple were identical in construction to those used for pear, except for the size. To ascertain the

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[1]Paper No. 153 of the Journal Series, New Jersey Agricultural Experiment Station Department of Entomology.

[2]"Plum Pollination." Hendrickson, A. H. Cal. Agr. Exp. Sta. Bull. 310. 1919.
"Pollination of the Apple." Lewis, C. I. and Vincent, C. C. Ore. Agr. Exp. Sta. Bull. 104. 1909.
"Studies in Apple Pollination." Morris, O. M. Wash. Agr. Exp. Sta. Bull. 163, p. 1–32. 1921.
"Pollination of Pear Flowers". Waite, Merton B. Div. of Veg. Path. Bull. 5. 1895.

extent of possible cranberry pollination by honey bees two equal areas of cranberry bog were inclosed in 12 mesh wire netting cages although a cheesecloth covering on the ground inside the cage was not used because of the habit of growth. The treatment in all three cases was alike; one cage had bees; the other did not. At the end of the blooming period the flowers of the pear and apple trees which did not set fell upon the cheesecloth and were counted. The unfertilized cranberry flowers persisted and were counted direct. The number of fruits was determined in all three cases. It was then a matter of arithmetic to arrive at the percentage of set. The data for pears is shown in Table 1, for apples in Table 2, and for cranberries in Table 3.

TABLE 1

| | Blossoms | Fruit set | % Fruit set |
|---|---|---|---|
| With Bees | 8751 | 428 | 4.08 |
| Without Bees | 6479 | 7 | 0.1 |

TABLE 2

| | With Bees | | | Without Bees | | |
|---|---|---|---|---|---|---|
| | Blossoms | Fruit set | % Fruit set | Blossoms | Fruit set | % Fruit set |
| Wealthy | 3475 | 591 | 17.0 | 3675 | 148 | 4.07 |
| Jonathan | 2758 | 238 | 8.2 | 1985 | 16 | 0.8 |

TABLE 3

| | Blossoms | Berries set | % Set |
|---|---|---|---|
| Cranberries with Bees | 2385 | 1335 | 56. |
| Cranberries without Bees | 2184 | 185 | 8.4 |

From an inspection of these tables it is apparent that the honey bee is an effective agent in the pollination of pears, apples and cranberries. The variation in the percentages of set is due to the differences in the nature of the plants.

Recognizing that honey bees are not the only agents of pollination thorough collections of other insects were made over an area of approximately 10 acres of pear orchard, and 10 acres of apple orchard between the same hours each day during the blooming period. In the pear and apple orchards the numbers of individuals and species were surprisingly small. A total of 29 syrphids, 213 chironomids, 46 muscids, and 3 bumble bees was secured in six collections in which every effort was made to effect a catch of all insects seen on or about pear trees. On an equal area of apple orchard 78 syrphids, 419 chironomids, 83 muscids, and 6 bumble bees were caught in six collections. The average population of known pollinating agents on cranberry bogs was 3 leaf cutting bees, 5 syrphids, and 448 bumble bees (mostly *Bombus impatiens*) to the acre. The collections in the pear orchard were between April 23 and May 1, in

the apple orchard April 27 and May 9, and on the cranberry bog July 4–11. The differences in insect population, especially in the number of bumble bees, appear to be logically explained by reflecting on these dates. Thus there are more insects in the apple orchards than in the pear orchards and a very much larger number on the cranberry bogs. The collections in the apple orchards were a week later than those in the pear orchards, those on the bogs were two months later than those in the apple orchards. Taking into consideration the life histories of the insects it becomes evident that with average weather conditions at that time of year we should expect an increase, although the fact that the apple and pear orchards in these experiments were well cultivated and situated in an intensely cultured area, while the cranberry bogs are surrounded by waste land may have a very potent effect on the numbers of insects.

The necessity of the honey bee as an agent of pollination in pears, apples, and cranberries is an inverse ratio to the number of other insects present since it has been shown that honey bees are effective pollinators when other insects are absent. As the number of natural pollinating agents increases the need for the placing of honey bees as pollinators decreases. There are comparatively few pollinating insects in the orchards studied at blooming time. Calculations from the number of bumble bees, their average of 12 flowers visited per minute, their working day of 12 hours on cranberry bogs, and the number of cranberries per acre, show that there are enough bumble bees alone to visit every flower growing into a cranberry every day during the blooming period for a crop much above the average for New Jersey bogs. Obviously, honey bees are needed in certain New Jersey orchards; cranberry bogs in New Jersey have sufficient natural pollinators.

The placing of bees in an orchard was studied by a comparison of two methods of locating hives of bees in the orchard. The first method was that of setting groups of 10–12 hives 200–300 yards apart; the second that of using 4–5 in a group with adjacent groups 100–200 yards apart. A uniform scheme of counting the bees on trees at varying distances from the hives was employed. This system consisted of selecting four trees on the circumference of a circle of 25 yards radius having the hives as a center, and counting the bees on these trees which were designated North, South, East and West, then repeating this at radii of 50, 75 and 100 yards from the hives. The composite result of 4 counts in the pear orchards with groups of hives from 200–300 apart are given in Table 4

Table 5 is the composite result of 4 counts in the apple orchards in which the groups of hives were 100–200 yards apart.

TABLE 4

| Distance from hives in yards | No. Bees Counted on Trees N | S | E | W |
|---|---|---|---|---|
| 25 | 37 | 32 | 34 | 24 |
| 50 | 18 | 27 | 24 | 16 |
| 75 | 14 | 6 | 12 | 14 |
| 100 | 10 | 4 | 4 | 5 |

TABLE 5

| Distance from hives yards | Bees counted on trees N | S | E | W |
|---|---|---|---|---|
| 25 | 5 | 10 | 4 | 3 |
| 50 | 8 | 5 | 7 | 9 |
| 75 | 6 | 8 | 4 | 7 |
| 100 | 5 | 7 | 9 | 9 |

Table 4 shows that when 10–12 hives are placed over 200 yards away from other hives the number of bees per tree decreases as one goes away from the hives until when one gets 100 yards away there are few bees to the tree. In the orchard the transition from zones of distribution about groups of hives was noticeable from the hum given off from the flying bees. The hum died down until it was scarcely noticeable about midway between the bunches of hives. In Table 5 there was a larger number of bees on 4 trees 100 yards from the hives than on 4 trees at 25 yards. This is explained by the fact that having discovered that when groups of 10–12 hives placed 200–300 yards apart in the pear orchard gave an unequal distribution; the hives, when moved to the apple orchards, were placed 4–5 together 100–200 yards apart in an effort to get a more equal distribution over the orchard. This arrangement caused the zones of activity to overlap. This last arrangement was much the more satisfactory as it gave a more equal distribution of bees. That this statement is correct is evidenced by the fact that it was impossible to find any significant difference in the average number of bees per tree in the orchard.

An interesting sidelight is thrown upon the figures for the distribution of bees about hives in pear and apple orchards when a comparison of the numbers of bees with the weather records for the period during which the counts were made. This is especially noticeable with wind velocity which varied from 8 to 33 miles per hour. On three days when the wind was at the latter figure a bee in the trees was hard to find. Table 4 is constructed from the counts on days when the wind varied from 15 to 22 miles per hour. Apparently the bees were able to work when the wind

fell below 25 miles per hour over the orchard. The average daily temperature between 6 A. M. and 5 P. M. fluctuated between 52° and 59°F. with the relative humidity between 28 and 51.

SUMMARY

A study of the data obtained in these experiments indicates, first that the honey bee is an effective pollinating agent for pears, apples, and cranberries; second, honey bees are a necessity in certain apple and certain pear orchards because of the scarcity of other pollinating agents at blooming time and reasoning conversely they are not needed on certain cranberry bogs because there are sufficient bumble bees to insure a large crop. Third, it is indicated that the distribution of hives in the orchard 4–5 in a group 100–200 yards apart is better than the placing of 10–12 in a group 200–300 yards apart when the wind velocity varies between 15–22 miles per hour.

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## THE STATUS OF ISLE OF WIGHT DISEASE IN VARIOUS COUNTRIES

By E. F. PHILLIPS, *U. S. Bureau of Entomology*

ABSTRACT

The Isle of Wight disease of adult bees is found throughout Great Britain and France, and is present in parts of Switzerland and in South Africa. The mite, *Acarapis woodi*, causing the disease, has been found in Czechoslovakia. This species of mite has also been found in parts of Switzerland not in recognized association with a diseased condition of bees. Several countries have established embargoes to prevent the introduction of this disease and an effort is being made in Switzerland to eradicate it.

American beekeepers are deeply concerned that the disease of adult bees commonly known as the Isle of Wight disease shall not be permitted to enter this country. They have almost universally approved the provisions of the law of August 31, 1922, which prohibits importation of adult honeybees except under supervision for scientific and experimental purposes, as well as the regulations formulated for its administration. To understand what exceptions may safely be made to this general prohibition, as is provided in this law, it is essential that the occurrence of this disease in foreign countries be learned as rapidly as this has been determined by competent investigations and to this end a careful watch has been kept on the literature of foreign countries. A record up to November 1923 has been published in U. S. Department of Agriculture Circular 287, in so far as these records have been available. The details of these records need not be repeated at this time.

The Isle of Wight disease is known to be caused by a parasitic mite, *Acarapis woodi*, and in spite of the confusion of symptoms of the various diseases of adult bees, diagnosis of this disease may be made with certainty through the finding of this mite in the tracheae of diseased bees. Attention should, however, be directed to the fact that in Switzerland, at least, this species of mite has been found externally on bees and to a limited extent in their tracheae without any external evidence of a diseased condition of their hosts. In the records of Switzerland, a distinction must, therefore, be made between the distribution of the disease and that of these mites. No evidence has so far appeared that such an external occurrence of this mite is found in other countries, but it must be remembered that *Acarapis woodi* is a relatively new discovery, and in all probability a similar condition will be found elsewhere, when equally thorough investigations are made in other countries. In spite of this peculiar finding, no doubt has been thrown on *Acarapis woodi* as the cause of the Isle of Wight disease, nor is it indicated that this apparently harmless occurrence of the mite will remain so, nor that it may not at some later date, under favorable conditions, become actively pathogenic. It is clear that for the present the path of safety lies in preventing the introduction into the United States of all living specimens of this mite, whether or not it is obviously pathogenic at the point of origin.

The Isle of Wight disease has been found, through the identification of the causal agency, throughout Great Britain and France, in French Switzerland and in South Africa. The mite has been found throughout Switzerland and in Czechoslovakia, but records are so far lacking regarding the Isle of Wight disease in the last named country. The disease has been recorded as occurring in Germany and Italy but these reports are apparently not founded on investigations and for the present definite records are lacking for these countries. The mite has been reported as absent from Austria and Denmark, presumably as a result of at least some investigation, although the records are far from complete. It has also been stated, with no basis of investigation, that the mite is absent from Jugoslavija.

Further searches for the mite and for the disease which it causes have been continued in the United States during the summer of 1923, and the results are still negative, lending still stronger support to the supposition that this species is not present in this country. It is evident, however, that continued search for a number of years will be required before certainty on this point can be reached. For this reason the cooperation of all interested persons is requested in the sending of any apparent ab-

normality in adult bees to the Bureau of Entomology for examination, not only during the coming summer season, but regularly in the future.

The importance of the Isle of Wight disease is coming to be widely recognized by beekeepers of other countries. The astonishing discovery of a parasitic and pathogenic mite living internally in the tracheae of bees has naturally attracted much attention, not only among beekeepers but among scientific investigators, and many persons have been led to make some search for these mites. This has resulted in a rapid increase in the literature on the subject, most of which has been listed in the circular mentioned previously. The dangerous character of the Isle of Wight disease has also led beekeepers of many countries to fear its introduction. As a result of this interest, considerable attention has been given to methods for preventing the spread of the cause of the disease. The steps taken in the United States are well known. Australia, Jamaica, the Union of South Africa and the Dominion of Canada have embargoes which should serve to prevent the introduction of the disease. There seems to be an insistent demand on the part of Italian beekeepers to have an embargo placed on importations of all bees into that country, and if this disease has not already gained a foothold in Italy it is a matter of concern to beekeepers of all countries that it be kept out, since there is so great a demand for Italian bees.

The action of Switzerland demands special mention. As has been stated, the Isle of Wight disease occurs in several apiaries in different parts of French Switzerland, but in spite of that fact, the Swiss government has established a rigid embargo to prevent all further importations, probably based on a belief that the present cases of the disease are to some extent traceable to importations, although this seems rather doubtful. Efforts are being made through the apiary inspection service, which in Switzerland is developed to a high degree, to stamp out the cases of disease which are known to exist, and provisions have been made for recompensing the owners of such apiaries for the destruction of colonies, through the joint action of the federation and the several cantons. This effort at the extermination of this disease of bees will be watched with much interest by American beekeepers, since in almost all cases bee disease control has aimed merely to alleviate conditions with little thought of the ultimate possibility of extermination. If, as is believed, the disease in Switzerland has a limited distribution, the plan of extermination certainly seems quite the proper one, and it is to be hoped that it will succeed.

The situation with regard to suitable treatments for the Isle of Wight

disease still remains somewhat unsatisfactory. On the discovery of such a condition as this most beekeepers at once ask for some method of treatment by which the disease may be wiped out from the infested apiaries, and such a demand is natural. From the work done by Morgenthaler, Rennie and others, it appears that the most promising method of treatment so far found and advised, other than the destruction of infested colonies, is the building up of the colonies as rapidly as possible in the spring, in order that through the emergence of healthy young bees the colony may increase in spite of the death of older bees occasioned by the disease. This policy is exactly identical with the preventive methods used in this country for European foulbrood and if it works as well for the Isle of Wight disease as it does for European foulbrood, then the beekeepers of the infested regions will doubtless find themselves better beekeepers than they were before, and this improvement in beekeeping practices and consequently of the honey-crops may to some extent recompense them for their losses from the inroads of the mite. Recently there has appeared an announcement of some sort of treatment, apparently approved by Doctor Rennie, in which a drug is given to the colony, this drug being purchasable from specified chemists. This is strongly suggestive of the methods for the treatment of the brood diseases sometimes advocated abroad, and it is to be hoped that the drug treatment for Isle of Wight disease will not prove so disastrous to British beekeeping as have some of the uses of nostrums still advertised in foreign bee-journals. There has, of course, been no opportunity to test the efficiency of this drug treatment on the Isle of Wight disease in this country and therefore no effort has been made to pry into the apparent secrecy of the treatment.

From the facts now available, which it must be admitted are too meager, it seems clear that at this time it would not be safe to lift the embargo established by the law of August 31, 1922, from any foreign countries other than the Dominion of Canada. Importations of queenbees into the United States for the improvement of the stock of queenbreeders and for scientific purposes are at the present time demanded almost solely from Italy, Carniola and the Caucasus. Since thorough scientific investigations have not proved any of the territories specified to be free of the Isle of Wight disease, none of them may safely be exempted. Certain other countries, for example, Australia, probably have no Isle of Wight disease, and that country has placed an embargo against importations of adult bees from all countries except the United States. If there were occasion to import queenbees from Australia, the

matter of lifting the embargo might well be investigated, but for the present no such occasion exists, and the embargo may still stand. There is no reason for lifting the embargo as a matter of courtesy, in response to the exemption of the United States made by Australia.

While at the time the law was up for consideration a few beekeepers thought the provisions of the proposed law too drastic, apparently at this time such a feeling has almost wholly disappeared. It is to be hoped that beekeepers will continue to support this effort to prevent the introduction of still another pest of the apiary, of which we already have a full share in the brood diseases, Nosema disease, the waxmoths, and in fact all specific infections and infestations of the apiary all of which had their origin in other countries and all of which were introduced during the period when importations could be made without any precautions other than those which might be taken by the importer himself. In addition to the Isle of Wight disease, there is a brood disease described in Europe which probably does not occur in the United States, and there is another disease of adult bees, perhaps several, which occurs in Europe and of which we have no knowledge here. The existing embargo against the importation of adult bees should, therefore, serve to prevent not only the importation of the Isle of Wight disease but also the introduction of whatever other diseases or enemies of bees of all stages may occur in other countries, and if this can be done the slight inconvenience occasioned by the enforcement of the law will be many times repaid to American beekeepers.

NOTE: Since this paper was written, the occurrence of *Acarapis woodi* in South Africa has been disputed. The record appears to be based on poor interpretations of symptoms of adult bee diseases and not on the finding of this mite. The mite has now been found in Austria. No mites of this species were found in the United States in 1924. E. F. P.

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## THE RELATION OF STORES TO BROOD REARING[1]

By J. H. MERRILL, *Apiarist, Kansas State Agricultural College and Experiment Station*

ABSTRACT

While pursuing studies on the rate of brood-rearing of bees at the Kansas State Agricultural College, it was found that there was a very intimate connection between the amount of stores left with a colony of bees in the fall and the rate of its brood-rearing, or building up during the following spring. When a colony was well supplied with stores, it reached its maximum before the main honey flow began, whereas those colonies which were insufficiently supplied by stores did not reach their maximum

[1]Contribution No. 321, from the Entomolgoical Laboratory, Kansas State Agricultural College. This paper embodies some of the results obtained in the prosecution of project No. 126 of the Agricultural Experiment Station.

until after the honey flow was well under way. Furthermore, the maximum reached by the colonies which were insufficiently supplied by stores was not as high at the time it was reached as was the rate of broodrearing in the stronger colonies which were then on a decline. The economic importance of this is to call attention to the necessity of leaving plenty of stores in the fall rather than to leave a lesser amount with the intention in mind of feeding the bees in the spring, if necessary.

Bees are machines which are owned and operated by beekeepers for the purpose of gathering nectar and storing honey. The amount of honey which they will store will, to a large extent, be proportionate to the amount of understanding which the beekeeper has of their needs and their methods of working. Since nectar can only be gathered during a small portion of the year, it is to the interest of the beekeeper to see to it that his machines are all in good working condition prior to and during this working period. Those machines which are broken down with hard work during the winter must be replaced and a large number of new machines must be secured before the honey flow begins, which, in the case of bees, is accomplished by the rearing of brood.

How often have we heard beekeepers remark "I think I have left enough honey in my hives to carry the bees through the winter, yet perhaps I may have to feed them when it comes spring." Judging from this remark, it would appear that such a man was a careful beekeeper; furthermore, the fact that he intended to feed his bees in the spring if necessary might indicate that he had the welfare of his bees at heart. However, recent experiments conducted at the Kansas Agricultural Experiment Station show that this is a mistaken policy. At first glance it would not seem to make any difference whether the bees were fed in the spring or in the fall, provided the feeding was done before they perished. It is true that it would not make much difference to those bees which were in the hive at the beginning of the winter. However, it would make a marked difference in the amount of brood which would be reared in the year. Since the strength of a colony of bees depends upon the amount of brood reared previous to that time, spring brood rearing becomes a matter of vital interest to every beekeeper.

An experiment to determine the value of winter protection for bees was carried on at this station for four years. During one of these four years the results obtained varied so markedly from those obtained during the other three years that it is well worth while to examine the cause for this variation. In this experiment the number of bees was determined in the fall and again late in the spring. The value of different forms of winter protection was guaged by whether the hive showed an

increase or a decrease in the number of bees at the spring weighing. During the four-year period, the two story unpacked hives which were unprotected by a windbreak showed on an average 109 less bees than they had in the fall. However, during the one year that varied from the others, this hive had 1250 bees less in the spring than it had in the fall. The packed hives which were protected by a windbreak during the four years averaged 22838 more bees in the spring. Yet the same hive in the above mentioned year only showed an increase of 3800. Apparently both of these colonies had wintered well and would have been considered to be good colonies of bees, but the fact that they fell so far below the general average shows that they had failed to do all that might have rightly been expected of them. The explanation of this failure was found in the fact that both of these colonies were very low in stores. Their food supply was not completely exhausted, although it was nearly so. The direct result of this insufficient food supply was that neither of these colonies reared as much brood as did the others during that year, nor as much as they normally would have had at that date. The curtailing of brood rearing naturally resulted in a fewer number of bees than would have otherwise been the case.

Observations made during the summer of 1923 tended to further corroborate the statements made above. The amount of brood in eight different hives was determined at various times throughout the summer. Four of these colonies were well supplied with stores, while the others had barely enough to maintain existence. When referring to these colonies in this paper, the first named colonies will be spoken of as "those colonies with stores" while the other four will be mentioned as "those deficient in stores." The queens in those colonies deficient in stores were younger than in the other four and should really have performed better than the others throughout the season, due to this fact.

The first brood count was made on May 26 which showed the total amount of brood which had been deposited in each of the eight hives during the twenty-one days previous to May 26. At the beginning of this egg-laying period, those colonies with stores each had about twenty pounds of honey, while the others only had six pounds of honey. On May 26, the average amount of brood in each of the colonies with stores was 17,750, or a daily average of 845 for the twenty-one days previous to May 26. On this date the average amount of brood in each of those colonies deficient in stores was 12,958, or a daily average of 617 for the twenty-one days previous to May 26. The amount of honey which remained in each of these hives averaged 4⅜ pounds.

The weather was very unfavorable for the gathering of nectar during the last of May and early June, yet in those colonies with stores the rate of brood rearing increased, while it decreased in those colonies deficient in stores. The second determination of brood was made on June 18 and at this time it was found that those colonies with stores had an average of 19575, or a daily average of 932, twenty-one days previous to June 18. The other colonies had on an average 11,095 brood, or a daily average of 528, for twenty-one days previous to June 18. The amount of honey in each of these hives had decreased to two pounds.

The heaviest and practically the only honey flow in Manhattan during 1923 occurred between June 18 and July 11. At the end of this period the colony with stores had an average of 25,055 of brood, or a daily average of 1,050, for twenty-one days prior to July 11. Those colonies which had deficient stores had on an average 15,281 brood, or a daily average of 728, for twenty-one days and increased their stores to an average of twenty and five-eighths pounds.

The brood rearing records show that there were two peaks of brood rearing at Manhattan in 1923. One occurring during the first week in May and the other during the last of May and the first of June. Those colonies which reared the maximum amount of brood during these two periods were sufficiently strong in bees to gather a good surplus during the honey flow. It will be seen from the above figures that those colonies which were deficient in stores did not begin to rear their maximum amount of brood until they were able to replenish their stores from the field. Those colonies which had sufficient stores had reared their brood early enough in the season to enable them to take an active part in gathering the season's crop.

It might be argued that observations made during May, June and July could not properly be called observations on spring brood rearing. However, the importance of these observations is that they show that the conditions which were found to exist in the early spring when the stores were short continued to exist until nectar could be gathered from the field. It is this supposition which is deceiving to the beekeeper who has planned "to feed the bees in the spring if necessary." Since at any and every time he examines his bees he would find that they were not entirely destitute of food, and as he was constantly expecting the honey flow to begin soon, he would have more of a tendency than ordinary to postpone the feeding. The result of this is that the rate of brood rearing will be so materially lowered as to impair the efficiency

of the colony during the honey flow. The amount of honey lost during this period due to this weakened condition of his colonies would have been more than sufficient to maintain a maximum rate of brood rearing up to the honey flow.

Some of the conclusions which may be drawn from the above statements are: First, colonies well provided with stores will maintain a maximum rate of brood rearing even during unfavorable weather conditions. This can probably be explained from the fact that whenever the bees maintain in the hive a proper temperature for brood rearing, the queen will deposit eggs. During cool or cold weather the bees maintain this proper brood rearing temperature by consuming honey and indulging in muscular exertions. In other words, heat is generated by work. When there is a sufficient amount of honey to supply a large number of bees at the same time, then it will be possible for them to maintain the optimum brood rearing temperature regardless of what the outside temperature may be, such as is found during a cold spring. However, when there is only enough honey to supply but a small portion of the bees at a time, it would be impossible to maintain a brood rearing temperature unless the outside temperature approaches this mark. Second, the bees in those hives which are sufficiently supplied with stores will increase the amount of brood reared during periods when the weather prevents their going to the field, as will be noticed between May 26 and June 18. The reverse of this condition will be found to exist in those hives which are deficient in stores. Third, since those colonies which have an abundance of stores in the fall rear more brood in the spring than do colonies which are not provided with stores, it will be seen that the postponing of feeding until spring is dangerous practice. Fourth, there is a direct correlation between the amount of brood reared in hives insufficiently supplied with stores and the amount reared in those hives which have enough stores. Fifth, the most dangerous factor in postponing feeding until spring is that the conditions of those colonies with insufficient stores may mislead the beekeeper as to the necessity for feeding.

# THE RELATION OF *BACILLUS ALVEI* TO THE CONFUSING SYMPTOMS IN EUROPEAN FOULBROOD

By A. P. STURTEVANT, *Apicultural Assistant, Bureau of Entomology, Department of Agriculture*

ABSTRACT

In localities where European foulbood is prevalent and under conditions favoring its unchecked development, the disease often shows variations in symptoms, such as death of larvae after being sealed, more or less suggesting in appearance larvae that have died from American foulbood. *Bacillus alvei*, a purely secondary decomposing organism, which is always found present in such dead remains generally to the exclusion of most other organisms, is apparently the cause of these variations in symptoms and course of the disease. It has been demonstrated that *Bacillus alvei* produces the granular slimy consistency and old rubber-like condition of the dried scales as well as the excessively obnoxious putrid meat odor in such cases. This activity of *Bacillus alvei* is commonly encountered in regions of late honey flow, in seasons of failure, or where through indifference or neglect other factors cause weak colonies to be prevalent and the disease has been present for a considerable time. This condition at times even necessitates more drastic treatment than is generally required for ordinary European foulbrood.

European foulbrood is known as the disease which usually attacks bee larvae at an early stage of their development, while they still are coiled in the cells actively feeding. The first appearance of the disease is recognized by an uneasy movement of the coiled larvae and a slight yellowish decoloration. After death there develops the characteristic moist melting appearance and the larvae generally lie more or less irregularly coiled in the bottoms of the cells. These dead larvae and the resulting yellowish brown dried down scales are easily removed from the cells.

As is also well known and generally accepted, the cause of this disease is *Bacillus pluton*,[1] a small coccuslike or lancet shaped micro-organism with little or no decomposing functions. These organisms are presumably fed to the young coiled larvae in their food. The bacteria at once start to grow in the larval intestine, increasing rapidly in numbers. This rapid start or short incubation period is possible because *Bacillus pluton* is always in the vegetative stage, never forming spores. It is consequently ready to attack at once without the lapse of time necessary for spore germination. As a result in European foulbrood, in the early stages particularly, a majority of the larvae die before being sealed in the cells, while still coiled, *Baccillus pluton* by its activity having killed them.

In these typical cases of European foulbrood there also may be found larvae which have not died until after being sealed in the cells but generally prior to actual pupation and somewhat resembling American foulbroad in character. Such cases have been described by White as follows:—

[1]White, G. F. 1920. European foulbrood. U. S. Dept. of Agric. Bul. 810.

"The number of larvae that die of European foulbrood in capped cells after assuming an endwise position represents a very small percentage of the brood that dies of the disease. These remains may be found in practically all colonies in which the disease has been present for a sufficiently long period and in which a considerable amount of dead brood has resulted."

*Bacillus alvei*, a spore bearing microorganism, is commonly found present in such remains often in large numbers even to the exclusion of *Bacillus pluton* and all other organisms. Because of this fact Cheshire and Cheyne,[2] the first to describe *Bacillus alvei*, as well as numerous other of the earlier investigators, considered it to be the cause of what is now known to be European foulbrood. *Bacillus alvei* has since been proven by various investigators to be the active cause of no bee disease. "It seems probable, however," White states "that it plays a role in European foulbrood, but the extent is not fully known."

This relationship of *Bacillus alvei* to European foulbrood, particularly in connection with certain confusing variations in symptoms, has now become more clearly established. The examination of several thousand samples of European foulbrood from various localities in the United States, as well as experimental observations,[3] have demonstrated that such abnormal symptoms as the delay of death until after sealing, in which the dead material contains large numbers of *Bacillus alvei*, are much more prevalent than was previously supposed to be the case, and that *Bacillus alvei* probably plays an important role in the production of these variations. Furthermore it has been found that this disease often varies to such an extent in the manifestation of its symptoms, particularly as related to varying external conditions, as to cause more or less confusion in diagnosis with resulting losses from improper treatment. In fact, as a striking illustration, in 1918 a serious condition in parts of California was brought to the attention of the Bee Culture Laboratory, in which in many diseased colonies large areas of sealed brood were found to be dead, having somewhat the appearance of American foulbrood but not showing the characteristic ropiness. There was present also a very strong disagreeable odor similar to putrifying meat. Because of the confusion caused by these conditions the writer was sent to investigate the cause and explanation of the trouble. Bacteriological examination of 26

[2]Cheshire, Frank R., and Cheyne, W. Watson. 1885. The pathogenic history and history under cultivation of a new bacillus (*Bacillus alvei*) the cause of a disease of the hive bee hitherto known as foulbrood. Journal of the Royal Microscopical Society. Series II, Vol. V, Part 2, pp. 581–601.

[3]Sturtevant, A. P. 1920. A study of the behavior of bees in colonies affected by European foulbrood. U. S. Dept. of Agric. Bul. 804.

such different cases showed the presence of such dead sealed larvae containing large numbers of *Bacillus alvei* in all but six cases, in five of which six however *Bacillus alvei* was demonstrated to be present although in less numbers.

A study of these confusing symptoms found in European foulbrood based on the varying bacteriological aspects of the disease and as affected by varying external conditions, gives foundation for the following explanation:—

There are found associated with *Bacillus pluton* other organisms in varying numbers known as secondary invaders, none of which have been found to have any relation to the cause of death of larvae, which distinguishes them from the primary pathogenic organism. They are either present in the intestine in small numbers or invade the larva soon after death and start to develop in the tissues of the dead larva. In the early stages of the disease or in localities where it never is able to develop to any great extent, types of secondary invaders which are not actively putrefactive in function, and have little effect upon the typical symptoms, are predominant. Under these conditions as a rule only the typically coiled, yellowish, moist melting larvae or easily removed yellowish brown scales are found. Generally dead material of this type gives off only a sour yeasty odor if any, and is probably what is designated in Europe as "Sauerbrut."

European foulbrood is known to be primarily a disease of weak colonies.[4] When external conditions are such that the disease is allowed to run unchecked for some time, as in localities of late honey flow or where there has been a failure and the bees have become weakened and have not been stimulated to clean up, then other secondary invaders developing more rapidly come into prominence. It has been found that as the secondary invaders vary in character and prominence so the symptoms vary from the characteristic appearances (Sturtevant[3] 1920), all varying with the external conditions. Under these adverse conditions for colony development organisms with purely putrefactive functions begin to invade the body tissues of the larva at death and even seem to have the effect of influencing the course of the disease to such an extent as to cause confusing variations from the typical symptoms, such as delaying the time of death.

The most active and pernicious of the secondary invaders in European foulbrood is *Bacillus alvei*, mentioned above. *Bacillus alvei* belongs to

[4]Phillips, E. F. 1918. The control of European foulbrood. U. S. Dept. of Agric. Farmers' Bul. 975.

the group of aerobic saprophytic spore bearing bacteria and practically its only influence on the course of the disease carried out under the proper external conditions for its activity is to cause the putrid decomposition of the dead remains, which gives rise to the excessively obnoxious odor under these conditions.

*Bacillus alvei* is often found only in small numbers in the dead coiled larvae in the earlier stages of the disease, but in sufficient numbers compared with *Bacillus pluton* to have much affect on the appearance of the dead larvae at that time. Under such conditions as mentioned above *Bacillus alvei* seems to find more favorable conditions for its growth and soon outgrows all other secondary invaders. This is particularly true in weak colonies where through indifference or neglect the disease has been present for a considerable time. This also is brought about, as was found to be the case in southern California, by such conditions as long periods of slight nectar secretion during the normal broodless period, lack of winter protection, lack of spring stores, unchecked swarming, or any other factor causing weak colonies where disease is prevalent.

In such cases as described it is noticed that as the disease develops in the colony more and more of the larvae seem to be affected shortly after being sealed instead of while still coiled in the open cell. That is, death takes place at the period where normal sealed larvae are capable of moving about spinning their cocoons preparatory to pupation. This accounts for the irregular shapes and positions of many of the dead larvae in these cases. Large numbers of the vegetative rods and particularly the spores of *Bacillus alvei* are found in larvae dying at this age, at times to the exclusion of practically all other organisms including *Bacillus pluton*. Occasionally vestiges of the remains of these organisms may be found, however, by careful search. If some of this decaying material, which apparently contains nothing but spores of *Bacillus alvei*, is fed to colonies which are not sufficiently strong to combat the disease successfully, the typical early stages of European foulbrood in which *Bacillus pluton* predominates, will be the first to develop. The disease develops much more slowly from this type of inoculation than when freshly diseased larvae are used, showing, as has also been observed by White that the growth of *Bacillus alvei* must have a deleterious effect on *Bacillus pluton* probably eventually killing or attenuating most of those organisms present. This slowing up action also apparently accounts for so many of the larvae not dying until after being sealed in these more advanced stages of the disease.

The decaying remains have a dark brown color, quite different from

the typical European foulbrood coiled larva and a granular lumpy viscidity which is sometimes mistaken for the true ropiness of American foulbrood. The dried scales from these remains may lie fairly flat on the lower wall of the cells but more frequently are irregularly coiled up the side walls. They are easily removed as a rule entire and have the consistency of old dried rubber rather than being brittle and adhesive like the scales of American foulbrood. Furthermore, associated with this condition there is a characteristic odor as mentioned above, which is caused by the putrefactive activities of *Bacillus alvei*. The odor is markedly different than the glue pot odor of American foulbrood. It has been described as similar to that of decaying meat and is extremely offensive. This is without doubt what has been designated as "stinkenden Faulbrut" in Europe which is also characterized by the presence of *Bacillus alvei*.[5]

Some experiments were carried out in the laboratory shortly after the California investigations to demonstrate further that *Bacillus alvei* is the cause of this condition. A small piece of comb containing healthy larvae from 3 to 4 days old was removed from a colony and part of the larvae were killed by puncturing the body wall with a sterile dissecting needle. These were then inoculated with a loopful of an actively growing pure culture of *Bacillus alvei* and the comb placed in the 37°C. incubator. After about 48 hours incubation the various larvae were examined. Those which had not been killed and inoculated had all died of starvation but showed very little change in appearance and had no odor. Those which had been inoculated with *Bacillus alvei* had developed the slimy lumpy consistency and putrid foul odor characteristic of the abnormal sealed larvae found in such cases of European foulbrood as described above.

Colonies which have reached the stage where there are comparatively large numbers of remains which have resulted from the activity of *Bacillus alvei*, often respond with much more difficulty to treatment. The bees always leave the old rubbery scales until the last to clean out. This probably is partly due to the unpleasant nature of the material, as well as to the fact that these remains often are not as easily removed as the normal diseased remains. One case in particular which was observed in California appeared to require a combination of the usual treatment for European foulbrood with the shaking treatment. That is, the bees were

[5]Maassen, Albert. 1913. Weitere Mitteilungen über die seuchenhaften Brut Krankheiten der Bienen, insbesondere über die Faulbrut. Mitteilungen aus der Kaiserlichen Biologischen Anstalt für Land- und Forstwirtshaft. Heft. 14. April. pp. 48–58.

shaken from all the brood combs which contained these rubbery scales and they were replaced by foundation. At the same time the colonies were re-queened with Italian queens and strengthened by uniting. This treatment was successful in eliminating the European foulbrood where shaking alone had only weakened the colonies and re-queening had given insufficient stimulus to clean up.

It is, therefore, evident that although *Bacillus alvei* has no powers of pathogenicity, these organisms do have a marked influence upon the course and characteristics of European foulbrood if the disease runs unchecked until the colonies have become so weakened that they are unable to throw off the disease without vigorous treatment. When this takes place the treatment is not only more difficult but mistakes in diagnosis may occur because of the confusing symptoms caused by the type of decomposition resulting from the activity of *Bacillus alvei*, causing further loss to the beekeeper.

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## THE STORING AND RIPENING OF HONEY BY HONEYBEES[1]

By WALLACE PARK, *Associate in Apiculture, University of Illinois*

ABSTRACT

This paper deals principally with the activities of bees engaged in storing and ripening honey. The nectar-carrier, upon her return from the field, delivers her load to one or more house-bees. These house-bees then put the nectar through a process which apparently reduces its water content and probably permits of the addition of enzymes such as invertase. The process is described in detail. The partly ripened nectar is then deposited in the cells where further ripening takes place.

It is not uncommon in bee literature to find statements to the effect that when a bee brings in a load of nectar, she goes to a cell and deposits it there. While this probably does occur at times (A. C. Miller is reported by Allen Latham as having seen it, Amer. Bee Jour. Nov., 1907, p. 717), I have failed to see it in the many hundreds of cases which I have observed. My observations show that the field bee upon her arrival in the hive, soon delivers her load to one or more workers which may be referred to as house-bees. G. M. Doolittle, one of our best observers of bee behavior, brought out this fact sometime prior to 1901 as is indicated by the editor's note to one of Dr. Miller's "Stray Straws" which appeared in Gleanings in Bee Culture, December 1, 1901, p. 930. Another of our most careful observers, Allan Latham, writing in the American Bee Journal for November, 1907, p. 716, reported observations which

[1]The data for this paper were obtained while the author was connected with the Iowa Experiment Station.

substantiate those of Doolittle. Almost without exception, however, later writers on the subject have continued to expound the old idea that the field-bee deposits her load of nectar in the cell.

For the purpose of making observations, glass hives which contained two Langstroth frames, one above the other, were used so that individual bees could be followed from the time they entered the hive until they departed. For the purpose of observing bees at work inside the cells, one hive was so arranged that the bees built the combs crosswise in it. This provided a large number of cells having one side formed by the glass wall of the hive. Many of the observations were made on marked bees while others were made on unmarked bees which were followed every instant of the time they were in the hive. These studies have been carried on at intervals throughout the past five years.

## The Behavior of Loaded Field-Bees

It is commonly stated in bee literature that when a bee brings in a load of nectar, she goes to a cell and deposits it there. While this probably does occur at times, I have failed to see it in the many hundreds of cases which I have observed. The field-bee, upon her arrival in the hive, soon delivers her load to one or more workers which may be referred to as house-bees. So far, I have been unable to determine who first pointed out this fact, but my observations are completely in line with it.

The behavior of the loaded field-bee is worthy of special notice. She enters the hive with an air of importance. If the source from which she obtained her load is well known to the other fielders, she walks about until she meets a house-bee to which she gives a part of her load. Occasionally she gives her entire load to a single house-bee, but usually she distributes it among three or more. It has not been definitely determined why the fielder seldom disposes of her entire load to a single house-bee, but there are indications that it is because many of the house-bees already have a partial load.

If the nectar source is new or bountiful, the loaded fielder usually performs a peculiar dance, during which she shakes her abdomen vigorously from side to side, all the while running in arcs of circles, turning first to one side and then to the other. She is usually followed by four or five other bees and while she continues her dance, every now and then, one of the interested followers may be seen to leave for the field, until by the time the dancer is ready to depart, a dozen or more may have left the hive to search out the source of the rich find already discovered by the dancer.

At irregular intervals, the dancer pauses long enough to pass out a taste of her booty to one or another of the nearby workers. But soon she meets a house-bee to which she gives a considerable portion of her load. As they approach each other, the field-bee opens her mandibles wide apart and forces a drop of nectar out over the upper surface of the proximal portion of her tongue, the distal portion being folded back under the head. Assuming that the house-bee approached is not already loaded to capacity, she stretches out her tongue to full length and sips the proffered nectar from the tongue of the field-bee as shown in Plate 1, A. While the nectar is being transferred in this manner, the antennae of both bees are in continual motion and those of the one bee are constantly striking those of the other. At the same time, the house-bee may be seen to stroke the "cheeks" of the field-bee with her fore feet as if coaxing for more and more.

When the field-bee has disposed of her load, she may start directly for the field, but in most cases she first secures a small amount of food either from another bee or from a cell. But before making her final start, she almost invariably gives her tongue a swipe between her fore feet, rubs her eyes and often cleans her antennae. Then, with a quick look around as if taking her bearings, she sets off for the field in great haste.

The whole process of disposing of her load is often accomplished by the field-bee in less time than it takes to describe it. In a previous paper, the writer (1) presented data showing that field-bees seldom remain in the hive as long as ten minutes between trips and that when working under favorable honeyflow conditions, the most frequent interval spent in the hive was less than four minutes. A few instances were recorded in which a field-bee remained in the hive about an hour between trips, but these were exceptions.

## Behavior of the House-Bee

When the house-bee has received her portion of the field-bee's load, she meanders about the hive in search of a place where she will not be crowded. Here she usually takes up the characteristic position shown at B in Plate 2, having the long axis of her body in a perpendicular position with head uppermost. She at once begins to go through a series of operations which are illustrated diagramatically in Plate 3.

Starting with the mouth parts at rest as shown in the first diagram, the mandibles are opened wide and the whole proboscis is moved somewhat forward and downward. At the same time, the distal portion of the proboscis is swung outward a little, and a small droplet of nectar appears

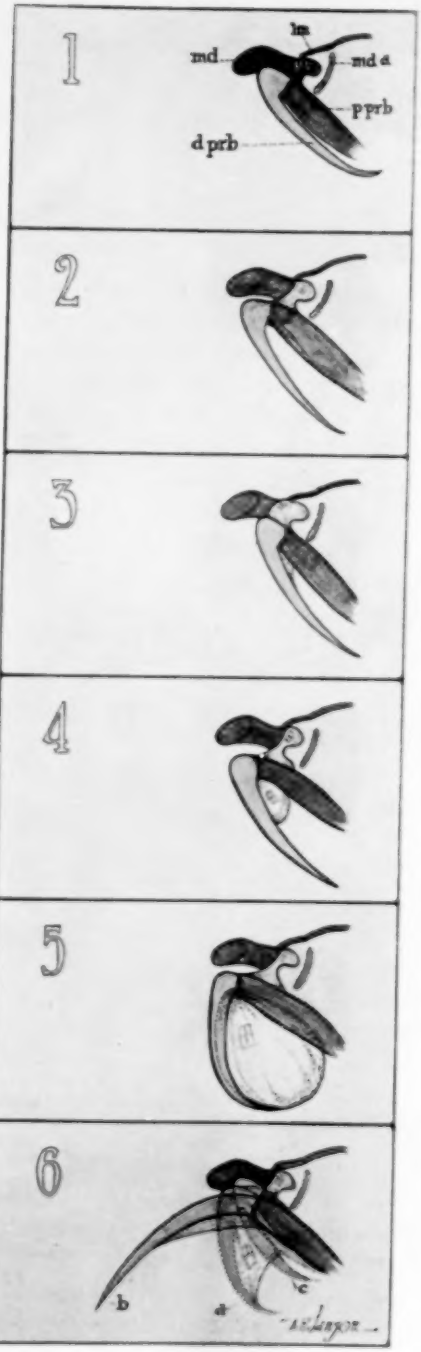
in the preoral cavity as shown in the second diagram. The whole proboscis is then raised and retracted almost to the position of rest, but is depressed again and is again raised as before, and so on. With each succeeding depression, the distal portion of the proboscis swings outward a little farther than before, but it makes only the beginning of a return to its position of rest.

Accompanying the second depression of the proboscis, an increased amount of nectar appears in the preoral cavity, some of which begins to flow out over the upper surface of the proboscis. As the proboscis is raised and retracted the second time, the beginning of a drop of nectar may usually be seen in the angle formed by its two major portions as shown in the third diagram. This droplet increases in size each time the proboscis is alternately depressed and raised until a maximum droplet is produced as illustrated by the fifth diagram. The bee then draws the entire drop inside its body. As the nectar begins to be drawn in, the drop assumes a concave surface at its lower end, as shown at *a* in the sixth diagram. The distal portion of the proboscis is extended as at *b* until the drop has disappeared when it is again folded back to the position of rest indicated at *c*.

A bee commonly spends from five to ten seconds in carrying out the series of activities illustrated in Plate 3. This procedure is repeated with only brief pauses for about twenty minutes, although both of these intervals are subject to considerable variation. Upon the completion of this part of the ripening process, the bee searches out a cell in which to deposit the drop she has been concentrating. Into this cell she crawls, ventral side uppermost as shown in Plate 2, C. This position is characteristic of a bee depositing honey. If the cell is empty, she enters until her mandibles touch the upper rear angle of the cell. The honey is forced out over the dorsal surface of the folded proboscis between the mandibles which are held well apart. Then, using the mouthparts as a brush, and turning her head from side to side, she "paints" the nectar across the upper wall of the cell so that it runs down and occupies the rear portion of the cell. But if the cell already contains honey, she dips her mandibles into the honey already there and adds her drop directly and without the "painting" process. Thus, my observations on the deposition of honey in the cell agree with those of Arthur C. Miller (2), and our observations on the ripening process differ mainly in that he had observed only part of the process.

When nectar is coming in rapidly, and particularly if it is very thin, the house-bees do not always stop to put it through the ripening process,

*A*, Nectar being transferred from a loaded nectar-carrier (upper) to a house-bee (lower). *B*, House-bee ripening honey. *C*, House-bee depositing honey.




Diagramatic sketches of the mouth-parts of a bee engaged in ripening honey

but deposit it almost at once. Instead of depositing the entire load in a single cell, the house-bee often distributes a load of such nectar by attaching a small hanging drop to the roof of each of several cells as shown in three of the cells in Plate 2, C. The hanging drop exposes a maximum surface for evaporation. Later, these droplets are collected and it is assumed that they are then put through the ripening process already described. Whether the nectar is ordinarily put through this ripening process more than once before it is fully ripened is a mooted question, but it seems probable that some of it may be worked over several times.

It has been generally assumed that the excess water is evaporated from the nectar after it has been deposited in the cells, although Von Planta (3) made analyses of nectar newly deposited in the cells and found that it was already considerably concentrated. He held the opinion that bees throw off a considerable quantity of the water while it is still in their honey-sacs. Latham (4), Brunnich (5) and others have held similar opinions. Whether or not such a method exists is not known, but it appears that the procedure described above has for one of its principal objects, the evaporation of water from the nectar. This is effectively accomplished by exposing the nectar in a thin film as it flows out over the proboscis. The drop which forms in the angle of the proboscis also exposes a relatively large surface for evaporation, and a noticeable reduction in the size of this drop is readily observed, as the drop is worked and reworked repeatedly. It seems probable, therefore, that this activity of the house-bees is responsible to a large extent for the concentration of the nectar, and that evaporation directly from the cell plays a smaller part than has been supposed.

Another important phase of the honey ripening process is the inversion of the sugar. Just how this is brought about is uncertain, but it is supposed that the inversion process is started by the addition of certain enzymes by the bee. If such enzymes are the product of some of the so-called salivary glands or other glands which have their outlets among the mouthparts, the process just described would provide ample opportunity for the addition of such substances.

## Literature Cited

1. Park, Wallace. Time and labor factors involved in gathering pollen and nectar. Jour. Econ. Ent., Vol. 15, April, 1922, pp. 129–134.
2. Miller, Arthur C. Bee behavior. ABC and XYZ of Bee Culture (Root), Ed. 1923, pp. 92–96.
3. Von Planta, A. *See* Nectar. ABC and XYZ of Bee Culture (Root), Ed. 1923, pp. 626–627.

4. LATHAM, ALLEN. Humidity. Amer. Beekeeper, Vol. 16, Feb. 1906, pp. 22–24.
5. BRUNNICH, KARL. About the bee's honey. Amer. Bee Jour., Vol. 59, Feb. 1919, pp. 56–57.

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## SPECIAL REPORTS PREPARED UNDER THE DIRECTION OF THE SUBCOMMITTEE ON INSECTICIDES AND APPLIANCES, COMMITTEE ON POLICY

### REPORT ON OIL EMULSIONS

Dec. 30, 1924

*To the Committee on Policy:*

Your sub-committee, appointed to summarize and so far as possible standardize oil emulsions, reports as follows:

Questionnaires were sent to entomologists in various states and provinces in the United States and Canada, including all who were known to have studied the emulsions. Replies with data were received from the following: W. P. Flint, Illinois; A. J. Ackerman, U. S. Bureau in Arkansas; C. A. Weigel and Miss B. M. Broadbent, U. S. Bureau in the District of Columbia; L. R. Taft, Michigan; L. Haseman, K. C. Sullivan, O. C. McBride and Turner, Missouri; W. M. Grube, graduate student, Missouri; T. F. Guyton, Pennsylvania; W. W. Yothers, U. S. Bureau in Florida; B. A. Porter, U. S. Bureau in Indiana; H. K. Plank and W. D. Whitcomb, U. S. Bureau in Louisiana; O. I. Snapp, U. S. Bureau in Georgia; E. P. Venables, British Columbia; A. L. Melander, Washington; E. J. Newcomer, U. S. Bureau in Washington; E. W. Berger, Florida; and J. J. Davis, Indiana.

The information contained in the questionnaires may be summarized as follows:

#### QUESTION 1.—FORMULAE FOUND MOST SATISFACTORY

The original boiled lubricating oil emulsion formula was generally recognized as the most satisfactory. This formula is,

| | |
|---|---|
| Oil | 1 gallon |
| Potash Fish Oil Soap | 1 pound |
| Water | ½ gallon |

(Many waters require up to two pounds of soap to maintain stable emulsions.)

Three kinds of cold-mixed emulsions were tested by many states and several found them quite satisfactory under certain conditions.

These formulae are as follows:

| | |
|---|---|
| Oil | 1 gallon |
| Copper sulphate | ⅛ pound |
| Hydrated lime | ¼ pound |
| Water | ½ gallon |

| | |
|---|---|
| Oil | 1 gallon |
| Calcium caseinate | 2–4 ounces |
| Water | ½ gallon |

| | |
|---|---|
| Oil | 1 gallon |
| Iron sulphate | ¼ pound |
| Hydrated lime | ¼ pound |
| Water | 1 gallon |

Melander reports the so-called W. S. C. miscible oil as having given the best results in Washington. This consists of 91 per cent neutral lubricating oil, 5 per cent potash

fish oil soap (30 per cent moisture) and 4 per cent crude cresylic acid. The last two are mixed to make up the emulsifier which is called Cresoap. The stirring of the Cresoap with the oil, without heat, makes the miscible oil.

### Question 2.—Kinds and Grades of Oil Most Satisfactory

At a conference of W. P. Flint (Illinois), B. A. Porter (U. S. Bureau, Indiana), A. J. Ackerman (U. S. Bureau, Arkansas) and J. J. Davis (Indiana), it was decided that oil must come within the following limits to prove satisfactory:

Viscosity—90–250 seconds at 100° F. (Saybolt)
Volatility—Less than 2 per cent
Specific gravity—0.87 to 0.93 at 20°C.

These were indicated as extreme limits and the questionnaires upheld this view. They indicate, however, that best results for scale control may be expected from oils bearing grades within the following limits:

Viscosity—180–220 seconds at 100°F. (Saybolt)
Volatility—Less than 1 per cent
Specific Gravity—0.88 to 0.91 at 20°C.

### Question 3.—Relative Efficiency of Boiled and Cold-Mixed Emulsions

The general conclusions were that the two were practically equal in effectiveness, there being an indication of a slight difference in favor of the boiled. The boiled was generally recognized as the more stable and it is advised that the cold mixed be made up only as needed.

### Question 6.—Physical Properties

The answers in general agreed in the following points: The oil emulsions, both boiled and cold-mixed are very adhesive, those with oils of higher viscosity being the more adhesive. When used with Bordeaux the adhesiveness is increased and when thus used on fruit may prove a disadvantage.

All of the emulsions have good spreading properties, no appreciable difference being noted between the boiled and cold-mixed. They may be of some value as spreaders when used in summer sprays on apple at 1½ to 2 gallons to the 200 gallon tank.

The cold-mixed emulsions show poor stability and should be made up as needed. The boiled is a thoroughly stable emulsion. Some difficulty was experienced with emulsions shipped when in a frozen condition.

The boiled emulsion mixes satisfactory with Bordeaux, arsenate of lead, and nicotine, but not with lime-sulphur. The cold-mixed is compatable with lime-sulphur as well as with the other sprays mentioned above.

The use of a weak (½–½–50) Bordeaux with the emulsion permits satisfactory mixing in most hard waters.

### Question 4 and 5.—Against what Insects has the Emulsion Proven Effective or Ineffective

All reporting indicated effective results against the San Jose scale, with a 2 per cent boiled or cold-mixed emulsion. A 3 per cent emulsion was thought advisable for very heavy infestations.

Favorable results for the control of the oyster shell scale by Venables but insufficient control in Illinois and in Indiana tests by Flint and Davis when 2 and 3 per cent

strengths were used as dormant. Good results were secured by Davis when the 2 per cent strength was applied soon after the young scales hatched.

Good control of green apple aphids was obtained with the 2 per cent emulsion by Flint, Porter, Newcomer and Haseman but this seems to be variable, although uniform results were obtained if applied just as tips of buds are showing green.

Only fairly good control of rosy apple aphis reported by Flint and Porter. Aphids (sp.?) were controlled according to Yothers and Melander, while unsatisfactory control of aphid eggs was obtained by Newcomer, Guyton and Haseman. Ackerman says that results in Arkansas are not sufficiently good to recommend for the control of apple aphids and that the emulsion is not as effective against apple leaf hoppers as is nicotine sulphate. Not satisfactory as a spray for potatoes because of injury to plant, according to Flint.

Satisfactory results were obtained against the leaf roller (*Cacoecia argyrospila*) by Melander and Venables. Guyton obtained a 100 per cent kill of eggs of the red-banded leaf-roller (*Eulia velutinana*) with a 1 per cent strength. The bud moth and oblique banded leaf roller, however, were not controlled according to Venables.

All armored scales and white fly on citrus were controlled, according to Yothers, but neither he nor Snapp found the emulsions effective against the cottony cushion scale (*Icerya purchasi*). Nor was Yothers able to secure satisfactory control of mealy bugs. Guyton destroyed 85 and 95 per cent of *Lecanium nigrofasciatum* with 2 and 3 per cent strengths, respectively.

Snapp and Whitcomb had good results against the following scales, *Pseudaonidia duplex*, *Chrysomphalus aonidum* and *C. dictyosperma*. Flint reports satisfactory control of the following scales on greenhouse plants, *C. aonidum*, *Aspidiotus hederae*, and *Lecanium tessellatum* with a 1 per cent emulsion. Weigel obtained similar results against *C. aonidum*. Flint reports that it cannot be used against the fern scale (*Hemichionaspis aspidistrae*) because of injury to plants, although effective against the scale.

The emulsion was ineffective against chinch bugs (Flint), only partially effective against rust mite (*Phyllocoptes oleivorus*) (Yothers), and it was less easy to reach and destroy the blister mite with the emulsion than with lime-sulphur (Melander).

Yothers found the emulsion satisfactory for red spider (*T. citri*), being more so than lime-sulphur, and Newcomer secured good control of the European red mite. Guyton reports 75 per cent control of this mite with a 2 per cent and 93 per cent with a 3 per cent strength.

Flint obtained control of the onion maggot with a 2 per cent boiled emulsion, plus 4–4–50 Bordeaux.

Guyton reports unsatisfactory results against the red bug (*L. mendax*) nymphs with a 2 per cent emulsion.

Chaffin of Georgia reports apparently satisfactory control of the Oriental fruit worm with one application of a ¼ of 1 per cent emulsion on peach, but these results are tentative as they are for only one season's work.

### Question 7.—Use of Bordeaux Oil Combination Against Plant Diseases

Yothers reports the Bordeaux-oil combination effective against such citrus diseases as melanose, scab, and ammoniation, according to Winston. Porter secured apparently good results against cherry leaf spot; Taft reports control of apple scab. Ackerman had as good control of blotch and bitter rot on apple where Bordeaux oil

was used as where he used Bordeaux alone. Several reported on the possible control of peach leaf curl and there are indications in favor of the combination but no positive results were reported. It is apparently too early to make definite recommendations except in the case of citrus diseases.

QUESTIONS 8 AND 9.—USE WHEN TREES ARE IN FOLIAGE AND EFFECT ON FOLIAGE

Oil emulsions are not generally recommended excepting as dormant sprays. The exceptions include, use as a summer spray where the San Jose scale is serious and has not been sufficiently controlled by the dormant treatment, and against the oyster shell scale. Melander and Newcomer recommend the 2 and 3 per cent emulsion applied during the summer as effective against red spider, while Plank and Whitcomb have used a 1 per cent oil effectively against *Pseudaonidia duplex* and *Chrysomphalus aonidum* if applied during the growing season when the maximum number of young are settling.

Severe injury to peach has been noticed by several experimenters if the emulsion is applied when the trees are in foliage. More or less injury has been reported to apple foliage and fruit from summer sprays, although only slight and insignificant injury except when temperature is above 90°F. Cherry, pear, plum, gooseberry, grape, blackberry, peony, lilac, cornus, rose, walnut, maple and onion foliage have been sprayed with a 2 per cent emulsion during the growing season without injury. Tomato and potato badly burned.

As a spreader it can be used safely at the rate of 1½ to 2 gallons to 200 gallon tank.

QUESTION 10.—COST

Cold-mixed emulsion is slightly less in cost than the boiled; the latter is cheaper than any of the commercial preparations and about one-half the cost of lime-sulphur.

Respectfully submitted,

Sub-Committee on Oil Emulsions.

JOHN J. DAVIS, *Chairman*
A. J. ACKERMAN
W. W. YOTHERS
L. HASEMAN

## WHAT IS THE STATUS OF SPREADERS IN OUR SPRAY PROGRAM

The sub-committee on spreaders is not in a position to submit a comprehensive report on its subject at the present time. Lateness in making appointments and the long distance existing between West and East has made it impossible to gather the desired information from the many distant sources from which this must necessarily come. The committee, however, has given the subject matter some thought which it deems worthy of presentation at this time. A committee should function during the coming year at the end of which time it should be in a position to submit a satisfactory report to this organization.

A survey and analysis of the experimental data available—which can not be considered more than fragmental at best—is far from satisfactory. The place of spreaders in our orchard or crop spray program is a matter upon which a majority of both entomologists and plant pathologists, closely associated with practical spraying work, find difficulty in assuming a definite attitude as to its worth. Results obtained to date—conclusions from which have been drawn on too small amounts of information per-

haps—always leave one in doubt as to the actual efficacy of spreaders as far as control is concerned. A summary of published information on the subject seldom, if ever, gives one a clear cut demonstration of the value of a spreader where compared to a block of trees sprayed without a material of this sort. The theoretical benefits at least appear to be outstanding in favor of spreaders. It doubtless is this theoretical benefit, coupled with good salesmanship on the part of spreader manufacturers that has brought about, and in fact, forced the usage of this material in our spray schedules. In the aggregate this usage is very extensive and costly. Thousands of dollars worth of casein spreaders have been used annually in many of the fruit growing sections during recent years—all of it without definite proof as to its real worth. Lack of complete information as to the value of spreaders as a means of increasing control of a given pest unarms most investigators and spray authorities. Spreaders can not be condemned nor can they be generally recommended without reservation. At the present time the proof is lacking.

Spreaders, as we know them today, have been over-emphasized so far as their practical value to the orchardist is concerned. This has been due chiefly to the propaganda of spreader manufacturers. But the possibility of greatly improving the efficacy of spraying by a suitable spreader—adhesive has not been over-emphasized. The subject of spreader-adhesives appears to be one of the most fruitful fields of spray investigation at the present time.

The committee did not send out a questionnaire to the various workers of the country as might have been done. It is doubtful whether this would have supplied information other than to further illustrate the lack of reliable information we have on the subject. On the other hand, that a more constructive report may be compiled during the coming year your committee recommends a committee be appointed early in the year to give the matter serious consideration and not only gather such information as it can from reliable sources, but endeavor to stimulate more interest and study in this important matter. This sub-committee believes the Committee-on-Policy of our Association should give this problem careful attention over a period of several years. The needed information can not be gathered at once. Thorough, comprehensive work of an extensive and intensive nature is required to settle the problems. The chemist, the entomologist and the plant pathologist must be called in to do this work. A few miscellaneous tests, conducted here and there, with irregular apparatus and conditions will not accomplish results. To a large extent we are now standing on data so obtained. To attain a proper solution demands the attention of several institutions. These institutions should be properly manned and so located that not only laboratory, but accurate and typical field work can be conducted. Doubtless the lack of necessary equipment has allowed the study of spreaders to drift to the point where we now find it.

The committee offers questions rather than answers at this time. This—a preliminary report—may assist in the compilation of future data on this subject. These questions, as now written, apply more specifically to casein-lime mixture but can apply to other materials, and are as follows:

1. What is the influence of spreaders in the toxicity of insecticides and fungicides?
2. To what extent do spreaders influence coverage of the many types of surfaces requiring spraying with the different types of materials used for this purpose?
3. To what extent is thickness of coverage influenced in our different spray materials by the addition of a spreader?

4. How is the durability of the coverage influenced by a spreader?

5. In the actual spraying operation is less spray used on a tree and given surface when a spreader is added?

6. To what extent does the addition of a spreader influence the speed of a spraying operation?

7. What amounts of spreader have given best results under general conditions? Have very small amounts, such as one ounce to 200 gallons, ever been found of benefit? What are the effects of large or smaller amounts of spreader on the amount of spray that adheres to the surface?

8. Does the addition of a spreader to a spray require a modification in the method of application? Should the spray be applied to the drenching point? Should it be added past the drenching point? What is the influence of the type of gun or rod used?

9. Would spraying around the tree quickly, in order to use as small amount of spray as possible, and then spraying around once again in the same manner give better spreading when a spreader is used? The purpose of spraying twice around the tree, or spraying quickly one-half the tree, and then going to another tree and spraying quickly half of that, and then returning to the first tree, is to permit static surface tension, equilibrium of the first droplets sprayed, so that when the second application is made a better film will be obtained with a much smaller amount spread. This probably is impractical, but theoretically, should give good results.

10. Would it be advantageous to apply spreaders for certain sprays during the season while it might be more advisable to omit the spreader in certain other sprays.

LOUIS A. STEARNS
R. H. ROBINSON
RALPH H. SMITH
LEROY CHILDS
*Sub-committee on Spreaders*

## RESULTS OBTAINED BY THE USE OF CALCIUM CYANIDE

Calcium cyanide has been reported as used experimentally in twenty-five states, and by several workers in the Bureau of Entomology in different parts of the country. In some of the states, work has been carried on by more than one experimenter sometimes in different departments. In most cases, dust, granular, and flake cyanide have been used, the dust being used in the pure and diluted forms.

But little work on the comparative effectiveness of different carriers for the dust has been done by any of those reporting. A combination of calcium cyanide and ground tobacco has been used in several states, and is apparently somewhat more effective than calcium cyanide alone, but is too expensive for practical work in most cases. Six experimenters have made some comparison between nicotine dust and cyanide dust, four reporting cyanide dust not as effective as nicotine, one reports it superior for the Grape Leafhopper, inferior for Aphids, most have found cyanide more dangerous to the plants with varying degrees of burning, and one more expensive.

The material has been used against the following insects: Pea Aphis,* Grape Leafhopper,* Cabbage Aphis,* Cherry Aphis,* Mound Building Ant,* Small Brown Ant,* Leafhopper Nymphs,* Onion Maggot,* Cucumber Beetle,* Squash Bug,* Potato Flea Beetle,* Asparagus Beetle,* Onion Thrips,* Clothes Moths,* Silver Fish,* Gooseberry Borer,* Grasshoppers,* Round Headed Apple Tree Borer,* Bat Bed Bug,*

*Some degree of experimental control has been reported in the case of these insects.

Potato Leafhopper,* Chinch-bug,* Fleas,* White Grubs,* Wireworms,* White Fly, Pear Psylla, Mediterranean Flour Moth, Cadella, Euonymus Scale, Pecan Weevil, Rosy Apple Aphis, Melon Aphis, Striped Flea Beetle, Green June Bug, Crickets, Cabbage Worm, Prune Borer, Strawberry Crown Borer, Squash Bug, Leaf Rollers, Apple Flea Weevil, Melon Aphis, Apple Maggot, Pear Midge, Quince Curculio, Mound Building Prairie Ant,* Rose Leafhopper, Green Apple Aphid, Saw Toothed Grain Beetle, and *Diabrotica 12-punctata*. It has also been used against the Garden Centipede and Nematodes.

Burning: All experimenters reported on this point have experienced from slight burning, to killing of some plants. In most cases, the heaviest burning has apparently occurred under conditions of high humidity or with moisture in the form of dew or rain on the plants. Burning has occurred in a number of cases under other conditions, and two experimenters are of the opinion that the weather had nothing to do with the burning. The work reported would indicate that moist conditions were more likely to give burning than dry conditions and that some plants are quite resistant to the action of the gas where others, notably corn, are very susceptible.

Only four of the experimenters replying to the questionnaire report that they are now recommending calcium cyanide for any insects. The insects for which the material is being recommended are: Household Insects, Clothes Moth, and Silver Fish, Chinch-bug, Fleas, and Wireworms.

Nine replies show that calcium cyanide has been used successfully against Woodchucks, Gophers, Rats, Ground Squirrels, Prairie Dogs, Gray Ground Squirrel, Striped Ground Squirrel, Bats in walls of houses, English Sparrows, Crayfish, and Moles.

Calcium cyanide has on the average proved very satisfactory and dependable in the control of Woodchucks and Ground Squirrels, but has in some cases been more expensive than carbon bisulphid, and poison baits when used against Prairie Dogs.

As a general summing up of the results of the experiments reported, it may be stated that work with calcium cyanide is in the experimental stage. Because of the danger of burning plants, and the uncertainty of the best methods and dosages for the control of most insects, further experimental work with the material must be done before it can be generally recommended. The majority of the experimenters report that they consider this insecticide has possibilities of much wider application. The reports are so inconsistent as to methods and results, that it seems advisable to place the work with this material on a uniform basis.

E. N. Cory
J. W. McColloch
W. P. Flint
*Sub-Committee on Calcium Cyanide*

## INSECTICIDE MACHINERY

In an attempt to gather information on insecticide machinery a questionnaire was prepared and mailed to a large number of workers thruout this country. Mr. Philip Garman mailed the questionnaires in the north-eastern states and eastern Canada; Mr. B. B. Fulton handled the middle western states and central Canada; Mr. R. H. Smith sent out questionnaires in the far western states and western Canada; and Mr. F. H. Lathrop mailed the questionnaires in the cotton states. The returns for each section were summarized separately by the individual mailing out

the questionnaires. The following general summary of the whole was then prepared from these sectional summaries.

A very satisfactory degree of interest was shown by the workers in answering the questionnaires, and replies were received from a number of the leading workers in this field. We take this opportunity to thank the many workers who assisted by giving the information which we desired.

The requirements with respect to Insecticide Machinery, varies in the several agricultural sections of the country. The large orchards of the highly developed fruit sections of the north-east demand large, high powered sprayers and dusters. A similar demand is apparent in the fruit sections of the far west. Smaller machines are somewhat more popular in the orchards of the middle west. In the southern section, where fruit growing is confined largely to peaches, or to small, newly developed apple orchards, economical production demands small, light machines, and even hand outfits are in demand.

This divergence of interest is shown in all types of insecticide machines whether for spraying or dusting purposes.

## Liquid Spray Machinery

Essential Features. The essential features of a successful orchard sprayer of course depends upon the requirements, and vary according to acreage, size of trees, topography, climate. prevalence of insect pests and diseases, nearness to water supply, etc. In general, the essentials are: lightness compatible with strength and durability; simplicity and accessibility of parts; tank low hung, and as large as can be handled easily; short turning radius; thorough agitation. The pump must be effective and should develop a pressure of from 250 to 300 pounds, with sufficient volume to supply as many guns or nozzles as are to be used with the outfit. The engine should be dependable with sufficient power to run the pump efficiently, but excessive power is not desirable.

Outstanding Developments. The past few years have been characterized by the development of large, high power outfits; by general improvement and simplification of the machinery; and by increased dependability. The "spray gun" has probably been the most spectacular development.

The Present Trend of Development. Apparently orchard sprayers have nearly reached maximum development so far as size and power are concerned and there seems to be a realization that unnecessary size and power are economically undesirable. The present tendency seems to be along lines of greater simplicity and reliability.

Suggested Improvements. Pumps should be simplified, and engines should be made more reliable. Better local up-keep service is badly needed in most orchard districts.

Sufficient Pressure. It is nearly unanimously agreed that the larger machines of recent models develop sufficient pressure. For rods 175 to 200 pounds pressure is sufficient, while guns require 250 to 300 pounds. While higher pressure, in itself, does not seem to be undesirable, it necessitates more expensive equipment, and increases the cost of operation.

Traction Sprayers. The traction sprayer seems to be more popular in the truck growing sections of New York, New Jersey, Pennsylvania, and West Virginia, than in other sections of the country.

Lightness, simplicity and reliability of construction, and the ability to develop sufficient and uniform pressure are essential features.

Commercial growers in the New York, New Jersey and Pennsylvania district have obtained satisfactory results in spraying a wide variety of truck crops, on farms varying from 5 to 30 acres.

In the middle west there is much dissatisfaction with traction sprayers, but various truck crops are treated with these machines in Ohio, Indiana, Illinois, Wisconsin, Kansas, Michigan, and Iowa.

GUN VS. ROD. The "spray gun" has come into very general use throughout the Pacific Coast fruit sections, in the middle west, and in the north-eastern orchard districts. It is also popular in the citrus groves of Florida and the Gulf Coast. In the fruit sections of Virginia it is less popular, and in most of the orchards of the south-east the gun is not generally used. In some sections of the middle west and of the north-east there is some tendency to return to the use of the rod.

It is generally agreed that the spray gun is a great time and labor saver, but it is not conducive to careful and thorough work. Much more care and experience are necessary in using the gun, especially with applications such as the "calyx spray."

HAND SPRAYERS. Hand sprayers are not popular for large scale orchard operations. However, for small orchards they are useful, and there are a number of uses for small, effective hand sprayers. There is much need of improvement in hand sprayers.

For larger work, the barrel type with horizontal double acting pump is popular. The wheelbarrow type is popular as an intermediate class. For a small outfit, the compressed air outfit is in favor, while a few workers mention the knapsack sprayer.

IMPROVEMENT is needed in ease of operation; lightness and strength of construction; and in agitation. Parts should be standardized and replacable.

## DUSTING MACHINERY (ORCHARD TYPES)

There is great interest in orchard dusting in the north-eastern and middle western fruit districts. Dusting is also practiced in the citrus districts of Florida and the Gulf Coast. In the south-east there seems to be a growing interest in orchard dusting equipment. In the Pacific north-west dusting has not come into general favor with orchardists, largely because of the prevalence of strong winds. Unfortunately, we obtained little information from California, where dusting has come into extensive use in some districts.

ESSENTIAL FEATURES. Workers in all districts are in agreement that the essential features of an orchard duster are in general a powerful engine and a capable fan; effective feed and cut-off; light, durable construction, low truck, flexibility in turning in orchards.

OUTSTANDING DEVELOPMENTS. Development of the self-mixing machine; general improvement in construction of engine, fan, and adjustments.

TREND OF DEVELOPMENT. The present tendency seems to be toward the development machines to handle heavier dusts, and machines that will mix materials in the field. Lighter machines are being developed with greater range of control of delivery, and with greater air velocity. Any tendency to reduce the price at the expense of quality or durability would be undesirable.

IMPROVEMENTS SUGGESTED. There is a need for improved mixing and feeding devices, and for a method to prevent packing of material in the hopper. There is great need for improvement in power transmission, and the use of a drive shaft and clutch in place of a belt is suggested.

ATOMIZATION AND DISTRIBUTION OF DUST. There seems to be no serious trouble in this respect, although many workers feel a need for improvement. Changes in delivery spouts and nozzles for this purpose are suggested.

VOLUME OF OUTPUT. Some of the better types of machines are satisfactory, but there is a general feeling that most machines lack power, and control is not satisfactory.

EASE OF HANDLING IN ORCHARDS is an important factor, lacking in some machines.

SELF-MIXING MACHINES. The self-mixing machine is too recent a development for workers to express definite opinions regarding it. There is much interest shown in this machine and, on the whole, workers seem favorably inclined toward it. No detailed tests appear to have been made to determine the uniformity of mixtures produced in such machines, but observations seem to indicate that nicotine mixtures are satisfactory.

Opinion of workers indicate that the self-mixing machine may replace other machines for certain purposes.

There is little evidence available at present to indicate the relative effectiveness of dust prepared in self-mixing machines and commercial dust of equal nicotine content.

Among the insects successfully treated with self-mixing machines are mentioned: Pear Psylla in N. Y.; Aphids and Red Bugs in Penn.; Aphids and leaf-hoppers in Mass.; Codling Moth, Curculio, and leaf-eating insects in Indiana; Codling Moth, Curculio, Canker Worms and other chewing insects (not necessarily by self-mix). For Aphids and sucking insects on other crops not so satisfactory on account of cost of material, Michigan; White Fly, Rust Mite, and Aphids in Florida; Walnut Aphids in California.

Growers seem to be favorably impressed with the self-mixing machine.

## DUSTING MACHINERY (COTTON, FIELD, TRUCK)

Growers in the north-east are interested in dusting machines for truck crops. In the middle west these machines are used for the treatment of truck crops, and to some extent for field crops. There is apparently little interest in this type of machine on the Pacific Coast, at least no answer to the questionnaire was received from that section. In the south great interest is shown in cotton dusting machinery and to somewhat less degree in dusters for truck crops.

ESSENTIAL FEATURES. Light, durable construction, adaptability to various crops, good feeding device, sufficient air volume and velocity, uniform distribution of dust from all nozzles. Machine should be constructed for easy manipulation on type of land for which it is intended. For cotton dusting, the air blast should be directed downward at 45 degree angle through the plant.

OUTSTANDING DEVELOPMENTS. General improvement and refinement of machines; lighter, more durable construction; development of machines especially designed for cotton dusting.

TREND OF DEVELOPMENT. At present there is a tendency toward light weight, durable, traction machines with good capacity and adaptability. Better machines at lower prices. Cheap machines lacking volume and durability are undesirable.

ATOMIZATION AND DISTRIBUTION OF DUST it is believed could be improved by providing more satisfactory feeding device.

OUTPUT AND AIR VOLUME AND VELOCITY. Power machines are satisfactory. Traction machines likely to be weak. Recent machines show great improvement in this respect. Larger fan revolving at lower speed may be more satisfactory.

SPECIALIZATION VS. ADAPTABILITY. Opinions vary as to desirability of developing machines especially designed for treating one crop. There seems to be a general feeling that adaptability is a desirable feature. A machine adaptable to a number of crops could be produced in large numbers, thereby reducing the price. Such a machine would also be economical for a grower producing several types of crops. On the other hand some crops, such as cotton, are produced on such large areas as to warrant the development of a specialized machine.

There is a general feeling that greater adjustability of outlets and nozzles would increase the usefulness of most machines. Providing interchangeable booms and nozzles, and canvas covers or trailers for different crops are suggested.

USES OF DIFFERENT TYPES OF MACHINES. The hand gun is useful for small areas, or for field corners, etc., not easily reached by larger machines. Hand machines permit greater care in placing the material. The crank type is better for plants in rows; the bellows types for plants in hills.

Traction machines save labor and time; they are useful on large areas. The size of the traction machine depends upon the size of area to be treated, and the topography of the land. The one-horse two-row duster is suitable for rough topography, and is large enough for most cotton farmers. Multiple row machines permit more rapid work. They are adapted to large acreages of level land. Such machines are popular in eastern truck districts; some machines covering as many as six rows.

IMPROVEMENTS. Hand dusters need greater air velocity, protection of moving parts, easier action, better carrying attachments, renewable parts.

TRACTION DUSTERS—more uniform distribution of dust from all nozzles, more constant distribution of dust regardless of variations in speed of team. Less weight, improved blowers and feeding devices, better construction, greater adaptability.

FRANK H. LATHROP
PHILIP GARMAN
B. B. FULTON
R. H. SMITH
*Sub-Committee on Insecticide Machinery*

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## ASSOCIATION OF COTTON STATE ENTOMOLOGISTS

*Annual Meeting, February 3–4, 1925*

This Association, organized more than ten years ago, held its annual meeting in Atlanta, Ga., Feb. 3d and 4th, 1925. The attendance upon the three full sessions held, exceeded two hundred (240), showing the growth of interest in economic entomological work in the South. This was the largest section of the Southern Agricultural Workers Association, in point of attendance.

The subject of greatest interest, as in past sessions, was that of the boll weevil and its control. Consideration of problems relating to calcium arsenate, supply and demand, and to the occurrence and control of the cotton aphis, where arsenical poisons are applied, were discussed by Mr. B. R. Coad, of the U. S. Bureau of Entomology, Delta Laboratory, Tallulah, Louisiana. Mr. W. D. Hunter, in charge of

Southern Field Crop Insect Investigations, was also present, and discussed the subject of balloon release experiments, in determining the direction and distance of insect dissemination, and also the status of the cotton hopper, or cotton flea, which in recent years, has done more damage in certain sections of Texas than has the boll weevil. Dr. W. E. Hinds, now Entomologist with the Louisiana Experiment Station, presented a paper on calcium arsenate and nicotine combinations for cotton aphis and boll weevil control. Preliminary small scale work has indicated that it may be possible to combine the nicotine sulphate with calcium arsenate as the carrier therefor, and, by this mixture applied as for boll weevil control, to obtain simultaneous control of both weevils and the cotton aphis, in night applications. The importance of still air seems to be much greater than that of high temperature, in securing effectiveness from this application.

Dr. Hinds also suggested a series of subjects for further standardization in experimental work, and in the matter of making records, to increase the comparability and value of the work done in different sections of the Cotton Belt. Along this line arrangements were made for another meeting of the Experimental workers, representing State and Federal laboratories to be held at Tallulah, Louisiana, early in March, for making definite plans for the season's experimental boll weevil control work.

Among other subjects of decided interest, was the spread and control of the oriental peach moth, which has now penetrated southward into Georgia and Alabama, and threatens to be a very important addition to peach pests in these states. Mr. O. I. Snapp, of the U. S. Bureau of Entomology, led in this discussion. In the matter of insecticides, lubricating oil emulsions were discussed by Mr. C. H. Alden, and new insecticide materials, relating particularly to sodium fluosilicate, were discussed by Mr. Marcovitch, of the Tennessee Station.

Mr. Lee Strong, Chief Inspector of the Federal Horticultural Board, was present, as the official delegate from the American Association of Economic Entomologists, and extended the greetings for that Association, from President Gossard. Mr. Strong then gave an illustrated lecture on Port Inspection work, with the illustrations referring particularly to the work done at the New York Port.

Round table discussions were also participated in by a large number of those present and the meeting, as a whole, appeared to be exceedingly interesting and helpful.

It was voted to make application to the American Association of Economic Entomologists, as a Cotton States section, to be affiliated with the American Association. It would seem that this recognition would be of help to both organizations, as well as aid in establishing economic entomology as a vocation, which may well be followed by a large number of Southern-born, and broadly trained, entomologists.

The officers for 1925 to 1926, include W. E. Hinds, Louisiana, President; R. W. Harned, Mississippi, Vice-President; G. M. Bentley, Tennessee, Secretary. A special committee, to represent the Association of Cotton States Entomologists, in connection with the Committee of the Association of Economic Entomologists, on quarantine matters, was appointed to include Wilmon Newell, of Florida; R. W. Harned, of Mississippi; and E. E. Scholl, of Texas.

W. E. H.

## Scientific Notes

**A Termite Attacking Seed-Cane in Haiti.** Dr. T. E. Snyder has recently identified as *Nasutitermes* (*Tenuirostritermes*) *pallidiceps* Banks, specimens of soldiers and workers taken from seed-cane collected in one of the fields of "Hasco" (Haitian-American Sugar Company) near Port-au-Prince, Haiti. So far as could be determined, this species builds no external nest or "niggerhead," at least in the cane fields, but lives in the ground, feeding on, and tunnelling thru dead roots of trees, manure and decaying vegetation in general. It attacks seed-cane soon after it is planted if it is at all slow in germinating, and may leave little more than a shell of the seed (top), by the time the shoot is a foot high. Under unfavorable conditions, the shoot may die from lack of nourishment ordinarily supplied by the seed before its roots can become established in the soil, and rarely is more than a single shoot obtained from a seed, none of the other eyes being able to start.

In fields where the termites are known to be most abundant, only seed dipped in acetate of lead, or the cut ends protected with tar, is planted. The selection of acetate of lead for a repellent is due to the accident of its being commonly used for other purposes in the sugar house.

Injury by this termite was reported to the writer by Mr. William Hanson, Jr., as early as 1918, but material had not previously been submitted for determination.

GEORGE N. WOLCOTT, *Entomologist,*
*Service Technique, Port-au-Prince, Haiti*

**A Pyralid-Pyraustinid Larva Attacking the Leaves of Sugar-Cane in Hispaniola.** No. 16 in the list of "The Insects of Sugar-Cane in Santo Domingo" (Journal of the Department of Agriculture and Labor of Porto Rico, Vol. VI, No. 1, January 1922, pp. 32–37) which is there reported as a "Pyralid with leaf-rolling larva, brown head, creamy opalescent body, not bred (reared) to adult. Common in young cane, tying together the leaves of the central whorl," has recently been identified by Mr. Wm. Schaus, thru the courtesy of Mr. J. L. Webb, from fresh material reared in Haiti, as *Marasmia trapezalis* Guenee. A parasite reared from the pupa has also been identified, by Mr. S. A. Rohwer, as *Spilochalcis* near *flavopicta* (Cresson).

In Haiti, the larva more usually folds over one edge of a single leaf and feeds on the adjacent upper surface of the leaf, which area quickly becomes light yellowish-brown. Such injured leaves stand out with startling prominence in a mass of otherwise green foliage, although the actual injury to the cane is negligible by comparison with that caused by some other pests.

Attacks by this larva on sugar-cane have not been noted by the writer in the adjacent islands of Cuba, Jamaica or Porto Rico, while characteristic lesions are rather common in most fields of young cane observed in Haiti (Hinche and Port-au-Prince) and Santo Domingo (Haina, San Ysidro and San Pedro de Macoris).

GEORGE N. WOLCOTT, *Entomologist,*
*Service Technique, Port-au-Prince, Haiti*

**The Food of Porto Rican Lizards.** In connection with Mr. G. N. Wolcott's extremely interesting and well carried out study on this subject, published as No. 4 of Vol. VII of the Journal of the Department of Agriculture of Porto Rico, the following observation may be of interest, not as showing any possibility of a large percentage

of consumption of a large moth by a small lizard, but as indicative of a greater amount of bravery—and therefore of usefulness in destroying fairly large insects—than would be expected of the small and apparently excessively timid lizard, *Anolis cristatelus* Dumeril & Bibron.

This lizard is very common in and about houses in Porto Rico and there are always several visible in my office perched on books and furniture. A few days ago on arriving at the office I noticed an exhausted moth of *Protoparce sexta* Joh., var. *jamaicensis* Butler, on the floor under a bookcase, occasionally beating its wings and describing small circles on the floor from which it was too weak to rise. A lizard of the above species, in length just about the same as the body of the *Propoparce*, had been attracted by the movements of the moth and was studying it from a respectful distance. Finally the lizard darted forward and seized the moth by the base of an antenna, hanging on in the face of a terrific beating from the wings of the moth until the antenna was finally pulled loose. After ten or fifteen minutes the lizard returned to the attack, catching the moth by the tibia of one of the front legs and again keeping its hold in the face of a vigorous wing-beating until the leg was removed. The moth was finally killed, but the lizard, after considerable investigation of the scaly body, finally decided that 'twas not very appetizing after all and abandoned its victim. The temerity of the lizard in attacking such a large insect, however, may explain in certain degree its ability to occasionally feed upon such large beetles as May beetles or root borers.

ARTHUR H. ROSENFELD, *Insular Experiment Station, Rio Piedras, Porto Rico.*

**Notes on Codling Moth Larvae.** While working with codling moth (*Carpocapsa pomonella*) ovicides the writer became curious as to how codling moth larvae enter an apple. By means of a small brush, newly hatched larvae were placed on Wealthy apples about two inches in diameter and watched.

The larvae wandered restlessly over the surface of the apple throwing the head from side to side and spinning a silken thread as they traveled. To make sure that a web was spun as they crawled, a bristle of a brush was passed on the surface of the apple close back of the worm and lifted. In many instances this procedure lifted the worm off the apple, suspended by a short silken thread.

Of the larvae watched, two entered the calyx where observation ceased, two found pitted or roughened places to enter, and three entered through the smooth skin of the apple. All larvae watched spun webs of silk for a foothold on the apple surface at the point of entrance, those entering roughened places to a less extent than those entering the smooth surface. Only one larva was successful in entering the apple on the first attempt. This larva crawled a short distance over the apple and stopped. It then passed the head back and forth many times until a somewhat net-like area of silk was produced. Holding to this silk with the thoracic legs, the head was pushed down against the apple and the mandibles opened and closed several times without cutting through the apple skin. The larva then spun more silk, strengthening its foothold, and tried again. This time the mandibles cut through the skin and the worm soon buried itself in the apple. It took approximately ten minutes for the larva to construct its foothold and cut the apple skin, and about an hour additional to bury itself. Another larva worked 40 minutes trying to cut the apple skin but was unsuccessful. After a rest of about seven minutes it abandoned the old place for a new try and was successful in the second attempt.

The third larva proceeded in a similar manner, making three futile attempts to enter in about two hours time. Dusk made observation so difficult that it was discontinued.

In entering the apple the larvae did not eat the material cut loose. Whether they ate any could not be determined by watching. It was cast aside and used to close up the entrance of the burrow.

Whether a foothold of silk is necessary in all cases for the larva to make an entrance is not known. Probably where two apples touch each other the larvae find it easier to enter as this seems to be a favorite place. Also, the calyx cup may provide a place of easy entrance.

JOHN L. HOERNER

**Emulsifying Agents as an Inhibiting Factor in Oil Sprays.** Experiments with highly refined lubricating oils as a spray for the red scale (*Chrysomphalus aurantii* Mask.) indicate that their insecticidal value is more a question of their mechanical properties, than of any inherent toxicity. Any oil of sufficient viscosity to form a non volatile film that will retain its consistency for several days, appears to be effective. Anything added to the oil that tends to prevent the formation or retention of this film becomes an inhibiting factor.

In a series of tests where the oil was kept constant at 2%, while the calcium caseinate, which was used as the emulsifier, was progressively reduced from 2% to .0078% the efficiency was markedly increased as the emulsifier was decreased. In a second series of similar tests this oil was reduced to 1%, and still there was a satisfactory kill with the lowest amounts of calcium caseinate.

A similar series of tests was made with whale oil soap as the emulsifying agent, the oil being kept constant at 4%, while the whale oil soap varied from 4% to 1%. The results showed a progressive increase in kill as the amount of soap was decreased, but with the least amount of soap used, namely 1%, there was not a complete kill of the scales.

In soap emulsions the oil is broken up into very fine droplets, each being surrounded by a tough elastic film of soap. The water itself appears not to be the active killing agent on the particular insect in question, yet it is the soap that comes in direct contact with the insect. This accounts for the fact that it requires from four to six times the amount of oil to get results in a soap emulsion as in an emulsion made with either calcium caseinate or lime.

In emulsions made with calcium caseinate, if too great a quantity is used it absorbs the oil. When reduced to the minimum (approximately a ratio of casein to oil of .5%) the oil is dispersed in large droplets which break down as they pass through the nozzle or on contact with the object being sprayed. An oil film is formed immediately; the water, being used merely as a carrier, rolls off.

The principle is strikingly demonstrated by spraying calcium caseinate emulsions similar to the first and last of the series, that is, oil 2% casein 2%, and oil 2% casein .0078% on a sheet of glass. The former will dry to a powder without any insecticidal value in 30 minutes, while the latter will remain liquid for several days.

Crude cottonseed oil, as well as petroleum oil was used in this series of experiments and gave equally satisfactory results.

From these tests and other evidence at hand it would appear that to secure the greatest insecticidal value from an oil, the oil should be applied as nearly as possible in the form of a mechanical mixture.

E. R. DEONG and HUGH KNIGHT,
*University of California, Citrus Experiment Station*

**Wax Moth Parasite.** Another parasite of the Greater Wax Moth, (*Galleria mellonella* L.) appeared at Fort Collins, Colorado,—identified by Cushman as *Nemeritis canescens* Gravenhorst. The presence of the wax moth in considerable numbers occurred in late summer, becoming so severe as to warrant fumigation. Cyanide proved very effective on eggs, larvae, pupae and adults. In spite of the apparent perfect control, several of the live adult parasites have been observed about the room at different times throughout the winter months, and in March are still emerging in small quantities.

R. G. RICHMOND

**Detailed Report is Made on Frost Damage.** One benefit to growers from the effects of the recent freeze is the great mortality to insects, especially those infesting citrus trees. While the loss of the foliage was comparatively light, considering the duration and severity of the cold, a careful examination of the remaining foliage indicates that a large majority of the scale insects and rust mites were killed. Effects seem to be about as follows on the different kinds of insects:

*Purple Scale*—Many of these scales have been examined and in practically all of them the adult scale appears to be dead. However, most of the scale coverings also contained eggs, which show no signs of injury whatever. A careful watch should be kept on these scales and when the eggs hatch and the crawlers emerge, a spray application should be made.

*Florida Red Scale*—In all of the examinations made, very few live Florida Red Scale have been observed. Crawlers present under the mother scale were also killed.

*California Red Scale*—Like the Florida Red Scale, this scale seems to be very susceptible to low temperatures, and a great majority of them have perished. Careful timing of the spray application in the future should keep groves—even those previously heavily infested—commercially free from insects.

*Chaff Scale*—Like the other scales mentioned this one seems to have been very well cleaned out.

*Rust Mites*—Very few living rust mites have been observed since the cold. However, the following statement by the writer was made about a year after the 1917 freeze in Florida and gives a very good idea of what might be expected of rust mites: "The almost complete extermination of this species by the freeze and its reproduction to billions in six months is a most remarkable biological fact. According to computation, one mite would have a progeny of about 12 millions in about 5½ months, and I believe this is just about what actually took place. . . . 'The sands of the sea' or the 'stars of the heaven' are the only expressions that will enable one to understand how abundant this species actually was the last of July and early August," (about six months after the freeze).

*Boll Weevil*—Due to the street report that this insect has been exterminated by the cold, it is deemed advisable to contradict this report. The boll weevil has not been exterminated by the cold. In fact a short while after the freeze, in examining an orange grove, we found an adult weevil hibernating apparently in good health. Further, since the weevils are not exterminated by the cold in northern cotton sections, there is no reason for expecting cold weather to annihilate them in the Valley.

Unless spray applications are properly made, the scale insects mentioned above will all show normal infestation before the end of the summer. Unless trees are dusted with sulphur or sprayed with lime sulphur solution, they will show an abundance of rust mites by the middle of the summer. The freeze has helped to the extent of keeping groves clean.

W. W. YOTHERS

# JOURNAL OF ECONOMIC ENTOMOLOGY

OFFICIAL ORGAN AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

APRIL, 1925

The editors will thankfully receive news matter and other items likely to be of interest to our readers. Papers will be published as far as possible in the order of reception, except that papers of reasonable length may be accepted in the discretion of the editor for early publication, at $2.50 per page for all matter in excess of six printed pages; in the case of other matter, the maximum of 2,500 words is still operative. Photo-engravings may be obtained by authors at cost.

Separates or reprints, if ordered, when the manuscript is forwarded, will be supplied to authors at the rates given below. Note that the number of pages in a reprint may be affected somewhat by the make-up, and that part of a page is charged as a full page. Carriage charges extra in all cases. Shipment by parcel post, express or freight as directed.

One hundred separates or reprints at $1.50 per page or plate. Additional hundreds or less, 4 pages or less, $1.00; 5–8 pages, $1.50; 9–12 pages, $1.75; 13–16 pages, $2.00; 17–24 pages, $3.00; 25–32 pages, $4.00. Covers suitably printed on first page only, 100 copies, or less, $4.50; additional hundreds, or less, $1.75. Plates inserted, $1.75 per hundred, or less. Folio reprints, the uncut folded pages (50 only), sixteen page signature, or less, $3.00.


Entomologists should be keenly interested in two articles, Darwin and Bryan—A Study in Method by Edward L. Rice and The Report of the Committee on Freedom of Teaching in Science in the issues of "Science" for March 6 and March 13 respectively. Both are excellent presentations of certain phases of an important matter. The contents are admirably adapted to the readers of that weekly, the better educated, broad-minded thinkers of the day. The arguments are absolutely convincing to a large group already well convinced. What effect will these pronouncements have upon the conservative "Defenders of the Faith" so numerous in certain sections of the country? What conclusions can be drawn from conditions in certain states where the teaching of evolution is prohibited by law? This is a democratic nation. The will of the majority prevails, at least within certain limits. Scientists have failed to lead the people in such states into the truth as revealed by latter day investigations. Is not this a fair deduction? There were times when such failures meant death. We can not escape the fact that man is man. Very few think things through to a conclusion. Too many opinions are ready made, inherited from ancestors, established by custom, sanctioned by usage. Yet man is inclined to be fair-minded if the matter is presented in an understandable way. To a large extent scientists have failed to reach the man-on-the-street. Scientists have been tolerated but not understood. This is an age of specialization and in all too many instances we have become so absorbed in technicalities—the origin of the Hymenoptera, for example—and have paid no attention to the broader lines of development so interesting to the average individual and so easily understood if presented in untechnical language. Only the other day the

editor ran across a newspaper man of some twenty years experience, but possessed of the most rudimentary notions of evolution and the processes involved in making "restorations" of extinct animals. He was typical of what proportion of the population? In many cases our science is too "highbrow" though this is much less true of economic entomology than in some branches of biology. It is quite possible that the conditions mentioned above are due as much to the specialization of the specialist, frequently a somewhat impractical chap, as to the blindness of the fundamentalist. A general understanding of the relationships and lines of development in both the animal and vegetable kingdoms would be the most effective refutation of the Bryanesque interpretations now so widely distributed by the really well-meaning secular and religious press. Knowledge of no practical use is not so extremely valuable. An understanding of the universe, of the forces which hold the stars in place, the laws which regulate life and define relations in this wonderful world of ours—all this is of great service in enabling man to correctly adjust himself to life as it must be lived. Scientists are under obligations to see that fellow men appreciate the majesty of creation—not the evolution of Darwin or the fundamentalism of Bryan—but the eternal verities in which resides truth, namely, God.

## Current Notes

Mr. Roger B. Friend of the Connecticut Agricultural Experiment Station visited the Boston Society of Natural History February 21.

Mr. Raymond C. Shannon, of the Division of Insects, U. S. National Museum, was married January 3, to Miss Elnora M. Sutherlin.

Dr. Vernon Kellogg, Secretary of the National Research Council, has been elected President of the Washington Academy of Sciences for 1925.

Mr. L. H. Weld has returned to his duties in the Division of Insects, U. S. National Museum, after a six months' leave of absence.

On January 8, Dr. A. G. Boving delivered his presidential address before the Entomological Society of Washington, his subject being "An Expedition to the Southeastern Shore of Iceland."

Mr. A. I. Fabis, Bureau of Entomology, who has been engaged in pecan insect investigations at Brownwood, Tex., has resigned from the service to enter the commercial field.

Mr. M. L. Gingell, Inspector of the Insecticide and Fungicide Board for the southwest district, has established headquarters at the Dallas, Tex., laboratory of the Bureau of Entomology.

Mr. Rodney Cecil, Junior Entomologist, Bureau of Entomology, stationed at Birmingham, Ala., has been granted leave of absence to attend Iowa State University for additional graduate study.

Dr. W. M. Mann of the U. S. National Museum, spent the last week of January in Boston studying types and consulting with Dr. W. M. Wheeler on the classification of ants.

According to *Science* Prof. Herbert Osborn is spending February and March in Cuba for the Tropical Plant Research Foundation, to study leafhoppers occurring on sugar cane and other plants there.

Mr. H. A. Adair of the Bureau of Entomology, who has been assisting John B. Gill in connection with pecan insect investigations at Thomasville, Ga., is now temporarily stationed at Brownwood, Tex.

Mr. C. R. Cutright of the Ohio Station spent a few weeks in January in the National Museum at Washington studying the plant lice or aphids under the direction of Dr. A. C. Baker.

Colonel Thomas L. Casey, the well-known Coleopterist, died at his home in Washington, D. C., February 3, and according to report, has left his library and large collection of Coleoptera to the U. S. National Museum.

Dr. H. C. Huckett of the New York Experiment Station, who spent most of the month of January studying the collection of Anthomyiidae, returned to his home at Riverhead, Long Island, on January 26.

On December 2, Mr. E. A. Vaughan of the Bureau of Entomology visited Port Saint Joe, Fla., to investigate a most interesting outbreak of *Dermestes vulpinus* in an establishment producing fish oil and fish scrap.

A Cornell University faculty party consisting of Prof. John H. Comstock, Mrs. Constock and Prof. Simon H. Gage, recently sailed from San Francisco aboard the President Hayes, bound on a trip around the world.

Dr. Carroll Fox, of the United States Public Health Service, has been working recently on the National Museum collection of fleas. Dr. Fox has completed a key to the genera of fleas for the world.

At the request of the National Furniture Warehousemen's Association, Dr. E. A. Back attended its midwinter meetings held at the Bon Air-Vanderbilt Hotel at Augusta, Ga., and gave a talk on the subject of storage pests.

Prof. J. S. Houser of the Ohio Station attended a conference of entomologists concerned with the preparation of oil sprays under the auspices of the Crop Protection Institute, held in Chicago the last week in January.

Messrs. E. M. Searls, Field Assistant, Madison, Wis., and N. F. Howard, Associate Entomologist, Birmingham, Ala., Bureau of Entomology, attended the Cincinnati meeting of the National Canners' Association and presented papers on the pea aphis and bean insects.

According to *Science*, Dr. O. A. Johannsen, Professor of Entomology at Cornell University, sailed for Europe on January 27. He expects to visit universities, biological stations and entomological museums in various countries, returning to the University in September.

Mr. W. O. Ellis, who for more than five years has been attached to the European corn borer investigational staff of the Bureau of Entomology at Arlington, Mass., resigned from the service on January 12 to enter private business.

Two bark-beetle outbreaks of considerable importance are in progress in British

Columbia; one on lodgepole pine at Martin Mountain, southwest of Chase, and the other on Douglas fir on the Pacific Coast, extending north from Sechelt.

According to *Science* the University of Pittsburgh in connection with its Charter Day exercises on February 27, conferred the degree of Doctor of Science, upon William Schaus, honorary Assistant Curator of the Division of Insects in the United States National Museum.

Messrs. M. B. Dunn and E. B. Watson are engaged at Ottawa in working over data concerning the 1924 outbreaks of Dendroctonus beetles on spruce at Frater, Ont., and the spruce budworm west of Lake Timagami, Ont. Some interesting results are being obtained.

The Division of Insects, U. S. National Museum, recently received an interesting gift of Coleopterous larvae from Dr. E. Rosenberg, Copenhagen Museum, Copenhagen, Denmark. This lot includes 21 different species belonging to 17 families, and is a very useful addition to the collection.

Mr. N. F. Howard of the Bureau of Entomology recently visited Chillicothe, Ohio, where he conferred with A. E. Miller regarding cooperative work on the Mexican bean beetle in Ohio, which is being conducted by the Bureau of Entomology and the Ohio Experiment Station.

Mr. B. Preston Clark has been in Washington since January 26, working with the Lepidoptera in the National Museum collection. Mr. Clark has recently purchased the Oberthur collection of Sphingidae, and with this addition now has the greatest collection of this family in the world.

According to *Science*, Dr. C. L. Marlatt, Chairman, Federal Horticultural Board, read a paper on "Plant Diseases and Insect Pests" before the 197th meeting of the Washington Academy of Sciences in Washington, February 19. This was a joint meeting with affiliated societies of the biological group.

According to *Science*, the University of Michigan Biological Station will hold its seventeenth session for instruction and research on the shores of Lake Michigan from June 22 to August 14. Courses in Entomology will be given by Prof. Paul S. Welch, Acting Director, and by Prof. H. B. Hungerford.

Dr. B. A. Porter of the Vincennes, Ind., laboratory of the Bureau of Entomology, spoke December 2 at Grand Rapids, Mich., before the Michigan State Horticultural Society, on lubricating-oil emulsion. He also talked before the Indiana Horticultural Society at Indianapolis, December 10, on fruit insect conditions in southern Indiana.

Dr. J. M. Swaine, Entomological Branch, Canadian Department of Agriculture, delivered a public lecture entitled "Insect Enemies of the Forest" at the Victoria Memorial Museum, Ottawa, on January 17, and again on January 21. On January 14 he broadcasted a short address on "Injurious Insects of Shade Trees" from the CNRO station.

According to *Science*, Dr. E. D. Ball, director of scientific work in the United States Department of Agriculture, has tendered his resignation to take effect March 4, 1925, to the new Secretary of Agriculture, President William M. Jardine, in order that the latter may have the freest opportunity to select his immediate associates.

Dr. N. N. Bogdonav-Katjkov is the author of an extensive bibliography of Russian Literature on Applied Entomology (principally Agricultural). It was published late in 1924 and contains 200 pages. Copies may be procured by addressing Mr. V. Grossman, Wolodarskij prosp. 37–39, Leningrad, Russia.

Mr. Oliver I. Snapp of the Bureau of Entomology, visited the A. & M. College, Miss., November 17 to 19 to discuss recent developments in peach insect control in the south before the annual meeting of the workers of the State Plant Board of Mississippi, and to assist in the organization of fruit insect investigations in Mississippi.

Prof. Geo. A. Dean, Bureau of Entomology, left Washington January 7 on an extended trip to the west, and has since inspected the green bug infestations in Kansas, Oklahoma, northern Texas, and Missouri. He consulted with the entomologists of the various State Experiment Stations and arranged plans for a thorough survey of the green bug situation.

Prof. G. M. Bentley is still Secretary-Treasurer of the Tennessee State Horticultural Society, the Tennessee State Nurserymen's Association and the Tennessee Beekeepers' Association, an office which he has held in each association for several years. At the convention of these associations at Nashville, January 27–30, in addition to his official reports, Prof. Bentley gave an address before each association.

Mr. J. C. Evenden, Forest Insect Field Station of the Bureau of Entomology, Coeur d'Alene, Idaho, attended the annual meeting of the Western Forestry and Conservation Association, held at Vancouver, B. C., on December 3, 4 and 5, 1924, where he presented a paper relative to the forest insect situation in the western United States. The paper was supplemented with an exhibit of photographic enlargements.

In connection with the meeting of the American Association for the Advancement of Science in Washington during Christmas week, an informal session of Federal and State Hessian fly workers was held at Central High School on the morning of December 31. This was attended by some 35 Federal and State entomologists interested in this study, and a very profitable and helpful discussion was held.

In the course of public lectures given weekly from January 4 to March 29, at the University of Minnesota, two are by entomologists as follows: "Spinners and Weavers of the Insect World" by William A Riley, professor of entomology and economic zoology, and chief of the division, (January 25), and "In Hawaiian Waters" by Royal N. Chapman, associate professor of animal biology (February 1).

Among the recent visitors at the office of Truck Crop Investigations, Bureau of Entomology, during January, were Dr. William Moore of the American Cyanamid Co., who conferred with Bureau officials regarding tests with calcium cyanide, and Dr. D. L. Van Dine, field director of the Tropical Research Foundation, who is in charge of the field investigations for the control of sugarcane insects and diseases in Cuba.

Co-operative work between the Division of Forest Insects, Entomological Branch, Canadian Department of Agriculture, and the British Columbia Provincial Forestry Branch has been arranged again for the coming season in connection with the control of the pine bark beetle in Southern British Columbia, and it is expected that the work being planned will bring about an effectual control of the beetle injury to yellow pine.

Dr. E. A. Back, Bureau of Entomology, visited the Thomasville, Ga., and Orlando, Fla., laboratories in October. Late in November Dr. Back was present by invitation at the fumigation of five million cubic feet of space in one of Buffalo's largest establishments. Dr. Back gave a talk on insects which attack household goods in storage before the Household Division of the American Warehousemen's Association, at Hotel Drake, Chicago, December 10.

Inspections of the farms in the neighborhood of Foley, Baldwin Co., Ala., have just been completed and no sweet-potato weevils were found in spite of the fact that a light infestation had been discovered in a potato curing house at Foley. Plans are now under way to conduct a second inspection at a later date in order to locate the infestation on the farms to permit eradication before the weevil has had an opportunity to spread.

Dr. J. M. Aldrich has received for study from the Vienna Museum the fifth lot of types of American Diptera. With this lot the total number of species has reached nearly 80. So far the shipment of types has been accomplished without any mishaps whatever, the packages going and coming without any damage. It is hoped that the study of the Vienna material may be continued in this way until all the American types of Diptera have been examined.

Mr. E. R. Buckell, Entomological Branch, Canadian Department of Agriculture, was absent from Ottawa from December 23–31, on statutory leave, visiting New York City and Philadelphia. While in Philadelphia, he carried on some grasshopper studies with Messrs. Rehn and Hebard at the Academy of Natural Sciences. Mr. Buckell was absent on sick leave during the last week of January owing to a slight illness which necessitated a brief sojourn in the Civic Hospital. He has now recovered and returned to duty.

The brown-tail moth scouting work in Nova Scotia is being continued and by February 14, a total of 118 winter nests had been collected. These were taken in the Bridgetown, Wolfville and Round Hill districts, the infestation in the latter district being a local outbreak of two years' standing; at this point 53 new nests and 3 old ones were found. This local outbreak further emphasizes the importance of keeping a careful check on the pest in Nova Scotia.

According to *Science*, the Board of Regents of the University of Minnesota has granted Prof. F. L. Washburn of the Department of Entomology a year's leave of absence to collect insects in islands of the South Pacific not visited by him on a previous expedition two years ago. It is planned to make collections on certain isolated islands of the Society group, and also in the Tuamotu Archipelago, consisting of over 70 atolls lying east of Tahiti, and formerly called Paumotus.

The Entomologists Group of the Professional Institute of the Civil Service of Canada held a meeting at Ottawa in the late afternoon of January 30. At this meeting the following officers elected for the year 1925-26 were announced. President, J. M. Swaine; Vice-President, L. S. McLaine; Secretary-Treasurer, W. N. Keenan; Delegates, Arthur Gibson and J. M. Swaine; Alternative Delegate, H. G. Crawford. The past useful services of the Professional Institute were briefly reviewed and the importance of the co-operation and support of all eligible members was stressed.

A successful conference of District Inspectors was held in the Offices of the Entomological Branch, Canadian Department of Agriculture, Ottawa, for six days commencing January 19. Messrs. Finnamore, Ryan, Fowler, Sheppard and Thompson attended, from St. John, N. B., Montreal, P. Q.; and Toronto, Niagara Falls and St. Thomas, Ont., respectively. General discussions took place concerning the enforcement of the Destructive Insect and Pest Act, and useful and interesting addresses were given by officers of the Entomological Branch staff as well as by officials from Branches of other Departments.

Mr. Henry L. Viereck, specialist in Hymenoptera of the Entomological Branch, Canadian Department of Agriculture, left Ottawa, March 10, and visited the Agricultural Experiment Station, New Haven, March 11, to examine some type material in the insect collection. He then went to the American Museum of Natural History in New York, the Academy of Natural Sciences, in Philadelphia, and the U. S. National Museum in Washington. He expected to sail for England on March 28, to visit the British Museum of Natural History, returning to Ottawa late in June.

Dr. J. H. McDunnough, Entomological Branch, Canadian Department of Agriculture, attended the meetings of the American Association for the Advancement of Science held in Washington, D. C., December 29–January 3. While in Washington, Dr. McDunnough took the opportunity to study numerous Tortricid types in the United States National Museum. On his return journey to Ottawa, he stopped off at Boston, Mass., and spent one day in the Cambridge Museum of Comparative Zoology studying Ephemerid types. These studies have enabled Dr. McDunnough to determine several species which were heretofore uncertain.

Recently the U. S. National Museum received the hide of a Panamanian howling monkey which was very heavily infested with the larvae of a bot-fly. The larvae have been determined by Mr. Green as belonging to the genus *Cuterebra*. This is the first known record of a species of this genus infesting any of the primates, its usual hosts being various species of rodents. The specimen was collected by Mr. Baer, who was with the Marsh Darien expedition, and was one of the last specimens obtained by him before his death.

The laboratory quarters occupied by E. E. Russell, in immediate charge of the seed chalcis investigation in the Yuma Valley, were destroyed by fire on January 25, including all the office equipment and records. These quarters were located in a building occupied by the Department of the Interior which was entirely destroyed with a loss of about $150,000. It is planned to continue the work at Yuma and to fit up temporary laboratory quarters as quickly as possible. In the meantime Mr. Russell is located temporarily at the entomological laboratory at Tempe, Ariz.

According to *Science*, an expedition has been arranged by the National Research Council in co-operation with the U. S. Navy and the Bishop Museum of Honolulu. The Navy has assigned the U. S. S. *Whippoorwill* for this purpose, Commander W. S. King in charge. Two trips will be made from Honolulu. The first will be to study Washington, Christmas and Jarvis Islands, and Professor C. H. Edmondson, zoologist, will be chief, and Mr. A. L. Whitney, entomologist. The second will be to the remote islands, Howland and Baker. Dr. C. Montague Cooke, zoologist, will be chief, and Mr. Edward L. Caum, entomologist.

Mr. A. B. Baird, in charge of the European Corn Borer parasite laboratory at St. Thomas, Ont., visited Ottawa on February 2 to discuss future plans concerning the importation and liberation of parasitic insects. During 1924, Mr. Baird's work chiefly consisted of rearing large numbers of the foreign parasitic species, *Habrobracon brevicornis* and *Exoristes roborator*. Over one million individuals of the former species were liberated during 1923 and 1924, and a total of over 15,000 of the latter, rearings of which were only undertaken in 1924. About 125,000 corn borer larvae were used in producing the above results.

At a meeting of the New York Entomological Society held on February 17th at the American Museum of Natural History, a paper was presented by Mr. E. Graywood

Smyth, formerly of the Bureau of Entomology, entitled "Habits and Food Plants of Some Mexican and Guatemalan Species of Epilachna, with Special Reference to the Bean Beetle." Attention was drawn to the serious nature of the northward march of the bean beetle, which has now reached the south shore of Lake Erie and is being diverted east and west. It is due to arrive in western New York, on the one hand, and south-eastern Michigan on the other, before the end of the present year, in spite of all efforts that may be made to check it. In Mr. Smyth's opinion the most effective way to check the pest is to give county agents in areas where it is expected special instruction in control of the pest, as given in Farmers' Bulletin 1407,and provide them with Riker mounts showing various stages of the beetle, with which to instruct the bean growers as to its appearance and damage.

At the request of several lumber companies and turpentine operators an investigation was made by R. A. St. George, November 22 to December 20, to determine the cause of the death of some 70,000,000 feet of pine timber extending over a territory from Alabama to Texas. Most of the dead and dying timber is located in western Texas, centered about Angelina County, but a considerable portion is in Louisiana. It was found that the various species of pine trees (longleaf, shortleaf, loblolly and slash pine) were dying from the combined effects of such agencies as drought, fire and turpentining. Bark beetles, usually of secondary importance (*Ips avulsus*, *I. calligraphus*, and *I. grandicollis*), attacked the trees while their tops were still green. A little later the trees turned brown and died. A preliminary study indicated that probably little summer wood had been added this year and that the drought was the primary cause of the death of the trees. Most of the trees appear to have died within the last three months.

A conference of Bureau entomologists interested in the study of the Hessian fly was held at the Bureau on January 5. The greater part of the day was devoted to a round-table discussion of methods of study, and particularly of statistical methods as applied to the determination of degree of infestation. Dr. L. O. Howard briefly addressed the conference concerning the attitude to be observed by the entomologists representing the Bureau in their contacts with the public. The following persons were in attendance: L. O. Howard, G. A. Dean, chairman, W. R. Walton, and J. S Wade, secretary, of Washington, D. C.; C. C. Hill, P. R. Myers, and H. D. Smith, Carlisle, Pa.; C. N. Ainslie, Sioux City, Iowa; G. G. Ainslie, Knoxville, Tenn.; W. B. Cartwright, Centralia, Ill.; J. R. Horton, Wichita, Kans.; M. C. Lane, Toppenish, Wash.; W. H. Larrimer, West Lafayette, Ind.; P. Luginbill, Columbia, S. C.; W. J. Phillips, Charlottsville, Va.; G. I. Reeves, Salt Lake City, Utah; and A. E. Satterthwait, Kirkwood, Mo.

The compilation of the proposed list of the insects of New York State is now to be completed. Dr. M. D. Leonard, who was appointed editor-in-chief while associate state entomologist of New York, returned to the department of entomology at Cornell University, in December, to again take charge of the project. His entire time will be devoted to the completion of this list and the New York State College of Agriculture has definitely promised publication, provided the manuscript is ready by June 1, 1925. It is estimated that over 16,000 species will be listed as definitely occurring in New York, together with as complete distribution data within the state as is known for each species. Several orders are already practically completed. Over one hundred of the leading specialists are actively co-operating. The editor of the list will apppreciate definite New York State records in all groups and will see that full credit is given to every co-operator.

An illustration of the function of the U. S. National Museum as a clearing house for economic entomological activity was furnished in the month of December. From the Government Entomologist of the Federated Malay States a series of specimens was received of a tachinid fly parasitic on a moth which is very injurious to coconut trees. The Entomologist wrote that he had endeavored to secure the identification of these parasites in other places, but without success. The species was identified; being new, it was described by Dr. Aldrich, and arrangements were made for the immediate publication of the description. Within a few days afterward Dr. J. D. Tothill, of the Canadian Entomological staff passed through Washington on his way to Fiji, where he has been commissoned to spend two years investigating a moth injurious to coconut. Of course his attention was immediately drawn to the parasite of this moth, which appears to be very abundant and beneficial in the Federated Malay States. He will immediately endeavor to introduce the same parasite into Fiji.

At the annual meeting of the Entomological Workers in Ohio Institutions at Columbus, Ohio, on February 6, 1925, the following resolution was adopted: *Resolved*, That this Association records its opposition to the shipment of New Jersey and Pennsylvania nursery stock with dirt on the roots into Ohio. The following program was carried out: Papers, August E. Miller,—Biological Notes on the Mexican Chigger Mite; C. R. Neiswander,—Biological Notes on Corn Insects; C. A. Reese,—Checking Results in Bee Disease Eradication; Richard Faxon,—Some Features of Insect Control in the Division of Plant Industry, 1925; E. W. Mendenhall,—Some Insects Found on Summer Inspection, 1924; Annette F. Braun,—Collecting in Southern Utah; H. A. Gossard,—Some Proposed Activities for the American Association of Economic Entomologists; J. S. Talbott,—The White Grub; A. W. Lindsay,—Vagaries of Genitalia; Chas. A. Weigel,—Calcium Cyanide as a Greenhouse Fumigant; F. L. Gambrell,—Calcium Arsenite; J. S. Houser,—The Tolerance of Conifers to Applications of Insecticides; James S. Hine,—Notes on Entomological Collections; R. C. Osburn,—The Alumni of the Ohio State University Department of Zoology and Entomology; D. M. DeLong,—The Factor of Personality in an Entomologist's Equipment; W. H. Larrimer,—Application of Statistical Methods to Determination of Percentage of Infection of Hessian Fly; F. M. Hull,—Dipterological Observations in South Dakota; R. H. Painter,—Life History of Texas Gall Insects; P. M. Swingle,—Digestion in the Cockroach; F. W. Poos,—Observations on the European Corn Borer; L. L. Huber,—The European Corn Borer; Geo. F. Knowlton,—Sugar Beet Root-Maggot of Utah; Walter S. Hough,—The Red-banded Leaf-roller; C. H. Kennedy,—Sugaring for Hymenoptera; H. C. Lewis,—Parasites of the Strawberry Leaf-roller; J. O. Pepper,—Parasites of the Bag-worm; E. L. Wickliff,—Insects in Fish Food.

The second annual meeting of the Entomological Society of Pennsylvania was held at the offices of the Bureau of Plant Industry, at Harrisburg on January 22. Twenty-one Entomologists were present, all workers in Pennsylvania except Mr. Chas. H. Richardson from Washington, D. C. The members present were: G. B. Stichter, Fred H. Worsinger, G. F. McLeod, F. J. Brinley, C. C. Hill, J. N. Knull, Floyd F. Smith, P. R. Myers, F. M. Trimble, F. L. Holdridge, J. G. Sanders, T. L. Guyton, H. E. Hodgkiss, S. W. Frost, C. H. Hadley, H. B. Kirk, J. R. Eyer, J. G. Carpenter, C. F. Doucette and F. F. Smith. The afternoon was devoted chiefly to discussion by members. Mr. Richardson addressed the Society on the subject

"Insect Physiology and its application to Economic Entomology." Mr. F. J. Brinley of the Federal Bureau stationed in Philadelphia, spoke on "Green House Fumigation." Mr. P. R. Myers of the Federal Bureau stationed in Carlisle, spoke on "Parasitism in the Hessian Fly." Prof. H. E. Hodgkiss of Extension Department, State College, spoke of Bee work, Orchard demonstration work and spray service. Secretary of Agriculture F. P. Willits spoke on the future possibilities of Agricultural work in Pennsylvania and approved the work that the Entomologists were doing; J. G. Sanders of the Sun Oil Company spoke of the great variability in oils. Mr. T. L. Guyton spoke of the Oriental moth work and Mr. G. B. Stichter of the Japanese beetle quarantine work in the vicinity of Philadelphia. After the general meeting the gathering adjourned to the Colonial Inn, where a banquet was enjoyed, followed by a short business session at which time Mr. C. H. Hadley and Mr. S. W. Frost were reelected as President and Secretary, respectively.

A communication has just been received from Mr. K. Y. Fey, Entomologist of the National Bureau of Entomology at Kashing, Chekiang, China, containing the following statement. "The rice fields of Chekiang province, have suffered very much from the calamities of the injurious insects at the recent several decades. The damages received are consequently at a degree of more than 40% than the total harvest. In the year of 1924 the Provincial Government of Chekiang established the Bureau of Entomology in Kashing, Chekiang, China. The responsibility of this Bureau is to research the injurious insects of rice and to guide the farmers in controlling the injurious insects. The work of this Bureau during last year, 1924, has decreased the calamity of the injurious insects very much and has increased the harvest to more than 30% comparing with the harvests of the year before last."

The North Central States Entomologists held their annual meeting at the New Union Building, Purdue University, Lafayette, Indiana, on March 5–6. As has been the case in previous meetings, no papers were presented, but a discussion was held of some of the important insect problems requiring special attention in the groups of states represented. J. J. Davis was elected Chairman of the meeting, and W. P. Flint, Secretary. The topics discussed were orchard insects, cereal and forage crop insects, insects affecting live stock, greenhouse insects, and truck insects. Special attention was given to the European corn borer problem, and the Mexican bean beetle. A very full discussion of the European corn borer situation was led by Mr. Caffrey of the Federal Bureau, Mr. Crawford of Canada, and Huber and Faxon of Ohio. The following men were present at the meeting: H. A. Gossard, J. S. Houser, L. L. Huber, T. H. Parks and Richard Faxon, Ohio; John J. Davis, F. N. Wallace, Harry F. Dietz, C. R. Cleveland, B. E. Montgomery, A. T. Wiancko, H. E. Enders, J. Troop, R. A. Montgomery and H. J. Reed, Indiana; C. L. Metcalf, P. A. Glenn and W. P. Flint, Illinois; S. B. Fracker, Wisconsin; R. H. Pettit and L. R. Taft, Michigan; J. W. McColloch, Kansas; L. Haseman, Missouri; D. J. Caffrey, Arlington, Mass.; Neale F. Howard, Birmingham, Ala.; B. A. Porter, Vincennes, Ind., A. F. Satterthwait, Webster Groves, Mo.; H. R. Painter, West Lafayette, Ind.; and W. B. Noble, West Lafayette, Ind., U. S. Bureau of Entomology; H. G. Crawford, Dominion of Canada. It was felt by all present that these meetings have been particularly helpful in correlating the work being done in this group of States.

## Horticultural Inspection Notes

Mr. Geo. H. Russell, an inspector of the Federal Horticultural Board, has been transferred from Del Rio, Texas to Eagle Pass.

Mr. F. M. O'Byrne has resigned his position as Chief Inspector of the Florida State Plant Board, and has been succeeded by Mr. J. C. Goodwin.

Mr. W. T. Owrey has been transferred from the port of Boston to Washington, D. C., where he will assist with the inspection work.

Mr. Raymond B. Haller, who was formerly stationed at Eagle Pass, Texas, is now at Del Rio, where he is assisting with the work of the Federal Horticultural Board.

Mr. A. C. Hill, a Plant Qurantine Inspector of the Federal Horticultural Board, has been transferred from New York City to St. Louis, to take charge of the work formerly handled by Mr. Harvey A. Horton.

Mr. L. A. Strong of the Federal Horticultural Board recently attended the meeting of Cotton States Entomologists held at Atlanta, Ga., where he gave an address on the subject of Port Inspection.

It has been found necessary to place an inspector at Douglas, Arizona, to look after the work of the Board at that point. Mr. Chas. E. Bellis has been transferred from Eagle Pass, Texas to Douglas to take charge of the work.

An important interception is credited to the Board's collaborator at Jacksonville, Fla., who found in the mail at that post office, a package from Cuba containing cotton bolls infested with living larvae of the Pink Boll Worm.

Mr. Marcus A. McMasters, who has been teaching Floriculture at the University of Maryland, has accepted an appointment as Plant Quarantine Inspector with the Federal Horticultural Board, and is stationed at New York City.

A bundle of broom corn manifested as whisk brooms was recently found in a cargo discharged from the S.S. "Ossa" from Italy, at the port of Philadelphia. The material was found to be rather badly infested with the European Corn Borer, *Pyrausta nubilalis* Hbn.

Mr. Harvey A. Horton, who has been with the Federal Horticultural Board since Mar. 1, 1919, has resigned his position as Plant Quarantine Inspector, to go into commercial work. Mr. Horton has been in charge of the work of the Board at St. Louis for several months.

An unidentified species of *Anastrepha* was recently found in New York infesting mangoes coming from Peru as ships stores. The Mediterranean Fruit Fly, *Ceratitis capitata* Wied. and the West Indian Fruit Fly, *Anastrepha fraterculus* Wied., have been taken lately in several shipments of fruit arriving at New York from foreign ports, and also at Providence, R. I.

The baggage of passengers arriving from foreign countries is a source of considerable danger in bringing foreign insect pests and diseases into this Country. This is illustrated by two interceptions made recently. A collaborator of the Federa Horticultural Board found a sack containing several hundred Citrus leaves in the suitcase of a passenger arriving at Key West from Cuba enroute to Tampa, Fla. The leaves were found to be infested with the Citrus Black Fly. The other interception was made at Seattle, Washington, where oranges from China infected with the Citrus Canker were found in the baggage of a passenger arriving at that port.

## Apicultural Notes

A new bee-journal, "Nederlandsche Imkersbond," has appeared from Holland. This has apparently taken over the older journal, "De Imker."

Mr. C. P. Dadant, the well-known veteran editor of the American Bee Journal, visited the Bee Culture Laboratory on January 24.

Dr. Max Küstenmacher, known internationally for his work on bee diseases and anatomy, died recently in Berlin at the age of 63.

Dr. J. W. Bulger has been appointed Assistant Apicultural Physiologist, in the Bureau of Entomology. Doctor Bulger recently completed graduate work at Ohio State University.

The Pasteur Institute at Paris, France, is at present devoting some attention to contagious diseases and enemies of the honeybee under the supervision of Professor Métalnikov.

Norway during the past year prohibited the importation of living bees, as well as combs with or without bees, to safeguard against foul-brood. Queen bees were excepted from this regulation.

Mr. Sepp Schmid, the editor of the *Bienen-Vater*, has compiled a list containing more than 125 names of different hives which have been on the market in Europe at various times.

Beginning with January 1 of this year, Spain has an independent bee journal, called "La Colmena." Prior to that time La Colmena had been published as part of the periodical, "Revista Social y Agraria."

Mr. E. L. Sechrist of the Bureau of Entomology took part in the short course in Apiculture given by Purdue University from February 16 to 20, and also attended the meetings at Carbondale and Elgin, Illinois, held February 23 to 24, and February 25 to 26, respectively.

A French balloonist found bees working on a piece of chocolate when at an altitude of 900 meters. At this height the bees even flew around the basket of the balloon. At 2000 meters with a temperature of —2°C. they lost their power of movement, and pitched down headlong.

Dr. Ing. Ctibor Blattny, of Czechoslovakia, reported in a recent issue of *Včelařské Rozhledy* that he has found all stages of the mite *Tyroglyphus*, probably of the species *Tyroglyphus longisetosus* Karpins, in the head and thorax of bees just dead. They entered the head by gnawing through from the thorax.

A prolonged drought in California in 1924 was responsible for what is said to be the state's poorest honey year on record. The average production in 1924 was only 30 pounds per colony. As a general rule, California produces about 10 per cent of the honey crop in the United States.

On December 4, the Southern Queen and Bee Association was established. This organization includes queen-breeders and package-bee producers. Queen-breeders have too long remained unorganized, and it is hoped that the association will fill a real need. Mr. D. E. Howell, of Shellman, Georgia, is President, and H. C. Short of Fitzpatrick, Alabama, is Secretary-Treasurer.

Prof. G. M. Bentley reports that a large class of students has registered in the course in general beekeeping at the University of Tennessee, and that about 15 will

take the course in advanced beekeeping. The University now has a good equipment for the beekeeping department, including 85 colonies of pure bred bees in modern hives.

The French Government has conferred the title of Chevalier du Mérite Agricole on P. N. Kunnen of Luxemburg. The recipient of this honor is Honorary Professor of Apiculture at Ettelbruck, a Vice-President of the International Apicultural Congress, and Editor of the *Bienen-Zeitung*, published in Luxemburg. Prof. Kunnen's name has appeared in the bee journals of America and Europe for many years.

Governor Sorlie of North Dakota has signed House Bill 112, providing $1,000.00 for bee inspection work in the State, and the bill goes into effect July 1st. This is late in the season for much real inspection work this year, but a start will be made. The best time for inspection work is early in the season, before much surplus honey is on the hive.

One of the last pieces of work done by Dr. E. F. Phillips, before his recent resignation from the Bureau of Entomology, was a compilation of existing information on the bee-louse, *Braula coeca*. This has now appeared as Department Bulletin 334 of the United States Department of Agriculture, and is the first worth-while American contribution on the subject. It was occasioned by the discovery of the louse in Carroll County, Maryland, in which locality it has been present for several years.

Mr. M. A. Perret-Maisonneuve, the author of "L'Apiculture Intensive et l'Élevage des Reines," was awarded on October 31 the Jean Thore prize of 1924 by l'Academie des Sciences for having written the best work on insects in the last two years. This prize confers the title "Lauréat de l'Institute," and a sum of 200 francs. The author has received a total of eight awards for this book since it appeared in 1923, and in addition has been elected an honorary member of the British Beekeepers' Association.

Mr. Jas. I. Hambleton, of the Bee Culture Laboratory of the Bureau of Entomology, attended the following beekeepers' meetings: Albany and Schenectady, New York, on February 2; Syracuse, New York, on February 3; and Buffalo, New York, on February 4. He also participated in the beekeeping short course held at Ohio State University, February 5–6. On February 12, Mr. Hambleton was at Johns Hopkins University in consultation concerning the new extracted honey-grader, and from February 25–27 he was engaged in locating a site in eastern Delaware sufficiently isolated for the purpose of certain field work to be undertaken this summer.

Mr. Edgar Gerstung in Germany, not to be confused with Dr. F. Gerstung, has announced a frame with metal lugs. Among other things he claims that the use of this frame does away with the inconvenience of having frames propolised, either together or to the hive-bodies. The bees may thus be handled with less disturbance because frames do not have to be pried apart. It will be recalled that certain frames with wooden end-bars so cut as to be self-spacing, failed to meet universal favor because the wooden projections used as spacers often became so propolised as to be split off in the process of separation from adjacent frames.

Doctor Borchert, of the Biological Institute at Dahlem near Berlin, after examining organisms found in healthy bees resembling those of the paratyphus group, has come to the conclusion that there is no ground for believing that the honeybee carries *Bacillus paratyphi B* which causes paratyphus in man. This work was done to test

the truth of assertions in German medical journals, and elsewhere, following a recent outbreak of human paratyphus in Germany that insects, especially the honeybee, spread *Bacillus paratyphi B* to the human race. Doctor Borchert in 1924 published a booklet on bee diseases entitled "Die seuchenhaften Krankheiten der Honigbiene." In this publication he is somewhat skeptical as to the existence of a paratyphus disease of bees as set forth originally by Doctor Bahr, in Denmark.

## Notes on Medical Entomology

Mr. F. M. Root, Associate in Medical Entomology at the Johns Hopkins School of Hygiene and Public Health, sailed January 3 for Brazil to make a study of the mosquitoes of that country with reference to the malaria problem.

At the invitation of the Departments of Entomology and Animal Husbandry of Iowa State College, F. C. Bishopp of the Bureau of Entomology gave a series of talks during farmers' Week in February at Ames, Iowa, on insects affecting livestock and poultry. He also addressed the Entomological Seminar and the Veterinary Club on subjects appertaining to medical and veterinary entomology.

Mr. O. G. Babcock of the Bureau of Entomology, stationed at Sonora, Tex., recently visited the Goodnight Ranch, Goodnight, Tex., for the purpose of examining bison and cattelo for cattle grubs and other parasites. The bison and cattelo were infested with cattle grubs to about the same extent as domestic cattle. An examination of carcasses of bison slaughtered for food did not yield anything of especial interest.

There has been much agitation in Texas during the past few weeks regarding new legislation appertaining to the cattle tick eradication work. The first bill passed by the Legislature was vetoed by the Governor on the ground that it worked too much hardship on the small cattle owner. A compromise measure has been prepared, and while it is not as strong as is desired by those in charge of the tick eradication work, it will probably be an improvement over the previous statute.

## Pacific Slope Notes

The Pacific Slope Branch will hold its meetings at Reed College, Portland, Oregon, June 17 to 20, in conjunction with the Pacific Division, American Association for the Advancement of Science.

Headquarters for both the biological and control work on forest insects, being carried on by the Bureau of Entomology in the Pacific States, has been established at Palo Alto, California.

Among those attending the Washington meetings from the Pacific Coast were Prof. Harry S. Smith, Riverside, Calif., Prof. R. W. Doane, Stanford University, Calif., Mr. M. C. Lane, Toppenish, Washington, and Roy E. Campbell, Alhambra, California.

The Dried Fruit Association of California, in a letter to the Secretary of Agriculture dated January 19, 1925, advises that its Executive Committee has appropriated an amount not to exceed $1,000 to augment the Federal appropriation for the study of insects attacking dried fruits.

Messrs. E. J. Newcomer and M. A. Yothers of the Bureau of Entomology, with headquarters at Yakima, Wash., attended the meeting of the Washington State Horticultural Society at Wenatchee, Wash., December 3–6. Mr. Newcomer read a paper on "Summer Oil Sprays" and Mr. Yothers discussed "Treehoppers, New Orchard Pests in the Pacific Northwest."

Mr. R. E. Campbell, Associate Entomologist, in charge of the laboratory of the Bureau of Entomology at Alhambra, Calif., on his return from attending the meetings at Washington, D. C., stopped over at Gulfport, Miss., and New Orleans, La., to confer with Bureau officials at those places regarding the pepper weevil and general truck pests.

Messrs. J. C. Hamlin and Curtis Benton, of the Dried Fruit Insect Investigations of the Bureau of Entomology at Fresno, Calif., have had an opportunity during the past month to secure valuable data on the effectiveness of HCN fumigation of sacked prunes. Five thousand tons of sacked prunes were fumigated in a modern warehouse.

Mr. David Dunavan, a recent graduate of Oregon Agricultural College, has been reappointed Agent of the Bureau of Entomology, to take charge of the truck-crop laboratory at Toppenish, Wash., where he will conduct wireworm investigations in co-operation with the Cereal and Forage Division and the Washington State Experiment Station. M. C. Lane, of the Cereal and Forage Division, will be in general charge of these studies.

Mr. J. C. Hamlin returned to the Dried Fruit Laboratory of the Bureau of Entomology at Fresno, California, on January 17, after visiting dried fruit interests in the San Francisco Bay region and the Sacramento and Santa Clara Valleys. On January 13, Mr. Hamlin was present at the annual meeting of the Dried Fruit Association of California, addressing that body in connection with the infestation problems. That evening he was a guest of the Association at its annual banquet at the Commercial Club. While in San Francisco, Mr. Hamlin conferred with Mr. E. P. Van Duzee of the California Academy of Sciences.

Mr. John E. Dudley, Jr., Associate Entomologist in charge of the pea aphis investigations at Madison, Wisconsin, laboratory of the Bureau of Entomology, has recently recovered from a serious attack of penumonia and is now in California, where he will work with Mr. Roy E. Campbell on the control of the pea aphis. The aphidozer will be given a thorough trial to test its efficiency in controlling the pea aphis under the conditions of growing peas in California. On February 19 to 27, Mr. Dudley and Mr. Campbell made a survey of the pea districts, and found indications that there would be an abundance of aphids. On March 2, Mr. Dudley addressed the Synapsis club of the Citrus Experiment Station, Riverside, California, on "The Control of the Pea Aphis in Wisconsin."

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**Arizona Boll Weevil, a Correction.** In the October JOURNAL (Vol. 17, No. 5, page 553), there appeared an abstract of a paper read by me at the June meeting of the Pacific Slope Branch of the American Association of Economic Entomologists, in which a serious error occurs. The Arizona boll weevil is therein referred to as *Phytonomus grandis thurberiae* Pierce. when of course, it should read *Anthonomus grandis thurberiae* Pierce. The error is inexcusable, but is my own mistake, due to lack of care in the hasty preparation of the abstract. Several years residence in the region infested with the alfalfa weevil, *Phytonomous posticus*, followed by several years in the native habitat of *A. g. thurberiae* may somewhat explain the working of the mind in making such an error.

CHAS. T. VORHIES